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(*Continued*)

Morning Session, Wednesday, January 2, 1918, 10.00 a. m.

PRESIDENT R. A. COOLEY: There appears first on our program "Entomological Extension Work in Pennsylvania," by Mr. C. H. Hadley.

ENTOMOLOGICAL EXTENSION WORK IN PENNSYLVANIA

BY C. H. HADLER, *State College, Pa.*

(Withdrawn for publication elsewhere)

PRESIDENT R. A. COOLEY: Here is a very practical paper, giving us a picture of conditions as they are and experiences. Do you wish to ask questions? If not, I will pass to the next title, "Planning a State Extension Project in Entomology," by Mr. T. H. Parks, of Kansas, which will be read by Mr. G. A. Dean.

PLANNING A STATE EXTENSION PROJECT IN ENTOMOLOGY

By T. H. PARKS, *Kansas State Agricultural College*

Today more than ever before is felt the need of extension work in applied entomology. This is due to the necessity of an effort being made to reduce waste at a time when crop values are extremely high and food

scarce. In the face of this demand made upon us, we must admit that the successful prosecution of extension work in applied entomology upon a project basis is still in the pioneer stage. This work has been carried out heretofore without prearranged plans and has been more or less sporadical as the needs of it were felt. Until recently the extension work in entomology has been of the nature of emergency work done by members of the Federal Department of Agriculture or State Experiment Station staff who have served in the capacity of members of a fire department subject to call upon the receipt of distress signals. These men have frequently arrived in time to find the crop already devastated, or at least so severely injured that little could be saved. As they are engaged in research work it is but natural (and the writer has been in this position) that they be more interested in getting information from the field than in giving it to the farmers. The time they could give to this work was necessarily limited and they have often been unable to outline and disseminate a plan of procedure that should prevent a recurrence of the trouble in question. Because these men have not been able to spend sufficient time in the field, farming interests have suffered heavily in the past through the state agricultural colleges and Federal Department of Agriculture being uninformed concerning insect injuries that are taking place.

The present shortage of some of our foods for export and home use has resulted in a realization on our part of the service we can render, and as a result many new men have been entrusted, during the past year, with the duty of taking our science to the field. This will probably result in extension entomology taking its place along with research and teaching work in all of the states.

The several entomologists now working under the federal and state Smith-Lever funds find one of their first problems to be the working out and successful prosecution of a definite project. The writer after spending four years in state extension work with entomology has come to the conclusion that this is not only the first but the main problem, and upon it will depend the success or failure of extension work. The difficulty encountered lies not so much in knowing how to plan the work, but to work the plan, which will have for its main object the reduction in amount of the emergency work to be done. This necessitates a thorough knowledge of state-wide crop conditions and working always just ahead of an insect outbreak if such threatens. For example, the men engaged in extension entomology in Kansas were preparing during the fall of 1917 for the grasshopper campaign of 1918, by locating and circulating knowledge of the egg-laying places of grasshoppers in western Kansas. This publicity was being done almost entirely by means of attractive exhibits of these grasshopper eggs

collected in the immediate vicinity. To the exhibit was attached a card of information of what was known about the location of the egg-laying places in that community and directions for their destruction by cultivation. The same plan is being followed with respect to control work with chinch bugs. Attractive exhibit boxes are being placed only in localities where the chinch bugs are again becoming abundant and promise to injure the crops in 1918. These show the tufts of sedge grass (*Andropogon scoparius*) which are the natural hibernating places for chinch bugs in Kansas, and the same after the back fire has burned it off and killed the bugs. Advance work with Hessian fly has given us knowledge which is of great value in carrying on extension work against this pest in 1918. For example our survey work has given us the exact localities of probable injury next year and has revealed the fact that only 50 to 60 per cent of the summer "flaxseeds" present in old wheat stubble in the infested localities gave up adult flies last fall, and that we may expect the remainder to reinforce the army of spring brood of flies.

We find that our project work must be outlined along the preventive course, and while these preventive measures are well known by us, they are either not known to, or the need for using them is not realized by, the busy farmers who often go blindly into the outbreak. One of the surprises of an entomologist entering upon extension work is to learn how little the average general farmer knows of injurious insects and their control, notwithstanding the volumes of literature that have been published, which may or may not have reached the farmer, or if so, may or may not have been read by him. Such knowledge makes it imperative to an active field worker that different methods must be used to have results of entomological investigations put into operation on the farms. The average farmer is tired of reading advice given gratuitously and wants to see you on his farm and talk with you about his conditions. This makes it necessary that the worker in extension entomology must be qualified to speak intelligently along other lines of agriculture and should have farm experience and an agricultural education. If he can bud, graft or prune correctly or can bind a sheaf of wheat by hand, the farmers' confidence is soon gained and the work of the entomologist made all the easier. Through your visit the farmer feels that he is in personal touch with the institution you represent, and the entomologist soon learns to know the methods that are practical for the farmer to use under present conditions. Getting information both to and from the counties is best accomplished through cooperation with the county farm bureau agents who understand the needs of their communities, and who through their local leaders are able to bring about a better community coöperation among farmers.

In counties having no county agent, local leaders should be found if possible and the work done through them. In Kansas, local men who through our visits have acquired a good knowledge of spraying are constantly called upon for help by others in their community.

Preliminary to the project work the extension entomologist must gather and systematize information from all sources that will be of value in his state. Much of this must come from co-workers in his college and this necessitates close coöperation with the departments of the college and especially the Department of Entomology. He should not overlook valuable information from other institutions and must serve as a sieve to separate out the published results of research work which will be of value in his state, and also see that the control measures selected thereby, before given to the farmers, are practical for them to use.

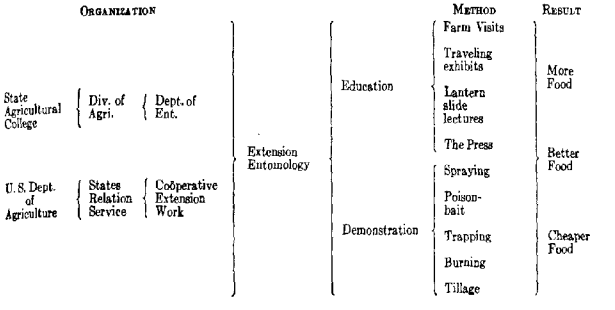
Planning the annual project in the field calls for a yearly program that will be continuous and efficient in addition to being in advance of emergency calls. The greatest part of the project work will consist in securing the application on a practical basis of the control work outlined, and this will call for perhaps 90 per cent of the time of the entomologist engaged in extension work. At the same time he will want to make some part of his control work research in nature to keep alive in him the love for new facts, and as Prof. R. A. Cooley states in his excellent paper read before the Special Meeting of this Association at Berkeley, California, in 1915,[1] to keep alive in him the true spirit of the scientist.

The extension entomologist has an excellent opportunity to see the results of control measures secured under different methods of farm or crop management, and, with his experience and training back of him, to wisely interpret the results secured by the average farmer under average farm conditions. This is illustrated by the work of a research nature done by the extension entomologist in Kansas during the season of 1916 with respect to the relation of Hessian fly damage to the presence of volunteer wheat in the seed bed at seeding time.[2] In 1917 an excellent opportunity was afforded to secure results of a research nature in demonstrating control work against grasshoppers in western Kansas. A comparison of the use of the Kansas poison bait against the hopperdozer showed that one application of poison bait killed 4.1 bushels of grasshoppers per acre, while repeated use of the hopperdozer under the same field conditions caught but 1 bushel per acre. Such work fits in well with the regular extension work in entomology and

[1] JOUR. ECON. ENT., vol. 8, No. 5, October, 1915.
JOUR. ECON. ENT., vol. 10, No. 2, April, 1917.

furnishes to the farmers convincing proof of the value of applying the best measures of control. Besides this it instills in the worker a desire to add to information which keeps him in closer touch with his science.

In the past our project work has been divided about equally between educational and demonstrational work. In most localities the need of the former is recognized before the latter can be most advantageously staged, and serves to make the work continuous throughout the year. The accompanying outline shows the relation of extension entomology in Kansas to the organization which is behind it, the methods used to reach the farmers and the ultimate result to be obtained.



The educational work represents the most that can be done with such insects as the Hessian fly, green bug and subterranean species with perennial habits. This branch of the work is by no means the least in importance, however, and when one can persuade a farmer by means of a personal visit to destroy volunteer wheat in his seed bed and wait until the fly-free date to sow his wheat in regions where Hessian fly is abundant, he is performing a real service and the farm visit is the surest way to bring this about. It is very important to plan these visits to be timely in order to secure the best results. The best time to make these farm visits, or auto tours, to observe the effect of volunteer wheat in the seed bed and the good of observing the fly-free date in sowing, is during March and April before the spring brood of Hessian flies has complicated the results. A visit at this time to wheat fields in one community in company with a group of farmers does more to convert them to using better methods against the Hessian fly than a front page story on the agricultural weekly. Farmers' institutes afford a good opportunity by which to present the educational work. In Kansas we have been using lantern slide lectures at these institutes and movable schools to acquaint the farmers with insect habits and the methods of control. We hope to replace these with moving pictures of insect control work, and the writer believes that moving pictures will in the

future serve as one of our best methods of educational work with entomology extension. Farmers' institutes and movable schools not only make the work continuous throughout the year, but also serve to prepare a community for demonstration work to follow. Many of our orchard demonstrations have been located as a result of these lectures and through which the communities were made ready for the spraying demonstrations.

Traveling exhibits have just been installed in Kansas and are expected to speak for themselves and give information at the right time for control. They are made up by the extension worker from material collected in the community and exhibited at public places only in communities where need for control is known. They are on display in one locality as long as the control method suggested can be applied during that year. The next year fresh exhibit material will be placed in that or other localities as the need for them is apparent. Care must be used in determining the places they are exhibited. In our eagerness to serve we are often forgetful of the fact that medicine is intended only for sick people and scatter our information in localities where it is not needed. The writer has often viewed the patriotic advertisement of an enterprising fertilizer company which copied the drawings and suggestions of the U. S. Bureau of Entomology in a publication on the Hessian fly and incorporating this with their fertilizer advertisement, had posters put up under glass in depots in western Kansas where the Hessian fly has never been known and where commercial fertilizers are not needed.

We find that exhibit material collected locally and showing the location of insects during the time of year they can be most easily destroyed, such as grasshopper eggs and chinch bugs, not only attract more attention than posters, but the suggestions accompanying are more apt to be used on the farms and thus an outbreak of insects disposed of in its incipiency.

Newspaper articles are of great value when timely and reach the largest number of people with least effort. Unfortunately we have no way of knowing how much good they do.

The demonstrational work gets the visible results and stands as an object lesson to the community. Work of demonstrational character must have the right of way and if possible be scheduled well in advance. Plans can be made for the control of fruit insects in advance, and one knows pretty clearly how much time the work will take. In Kansas spraying demonstrations for the control of fruit insects have been going on for seven years and are distributed throughout the eastern part of the state, orchards being accepted for this purpose under written contract with the owners.

These orchard spraying demonstrations admit of prearranged plans which are always carried out as scheduled. This is possible because one knows in advance what orchard insects to expect and when the spray must be applied. Consequently, the county agents and our cooperators on the farms know approximately when we shall be with them for supervising the spraying.

That part of the project covering the work with staple crop insects is subject to a moment's change. We are unable to anticipate in advance outbreaks of such staple crop insects as army worms, sod webworms, or army cutworms, and can combat them only as they appear. However, that part of the project covering staple crop insects calls for definite work for each month from March to December, and is prepared with a view to working in advance of outbreaks as much as possible. For example, the educational work in the field to reduce the injury from Hessian fly that will result in 1918, was started during March and April, 1917. At that time farm visits were made in sections where the Hessian fly is abundant and the farmers' attention called to the absence of Hessian fly in fields where good practices against the fly were used in seeding the wheat crop the previous autumn; likewise the abundance of overwintering fly in volunteer or early sown wheat. These visits bear fruit the following summer when these farmers prepare their ground for wheat. Owing to advance knowledge about the egg-laying places of grasshoppers in western Kansas, poisoning next year will commence in May, which is about two months before complaints come in from the farmers and before the insects have scattered.

Wherever advance information can be obtained it will help the extension entomologist to plan the yearly project and enable him to outline a program which, when followed out, will accomplish the most good with the least expenditure of funds. This should be the hub about which his project activities are centered. With this information at hand it is possible for the extension entomologist to install system into his work, and he is able to be on the ground in advance of an insect outbreak. Working his plan then consists in administering a "serum treatment" both to the farmer and his farm. It is too much to expect that the result will be to "immunize" against insect outbreaks, but if the entomologist is successful in carrying out his plans it will do much to reduce their frequency and violence.

PRESIDENT R. A. COOLEY: Do you wish to ask Mr. Dean any questions about this paper?

MR. HERBERT OSBORN: I would like to just make one remark—

that is, to emphasize that research work is possible for extension workers to do, but extension should not be drawn away by research. It does seem to me that if they have the right spirit, they can do a good deal of research work and it would be a very great advantage to them as well as to the station with which they may coöperate.

PRESIDENT R. A. COOLEY: I will now call for Mr. Hunter's paper, "Municipal Control of the Spring Canker Worm."

MUNICIPAL CONTROL OF THE SPRING CANKER WORM

By S. J. HUNTER, *University of Kansas, Lawrence*

During the last two years the spring canker worm has been unusually abundant and destructive in cities of the eastern half of Kansas, as well as in the native woods. This has afforded an excellent opportunity for the study of the biological problems connected with its life.

Since this phase of the work has recently been published in Bulletin No. 11,[1] of the Department, this paper will be confined entirely to the methods used in dealing with this insect in the city of Lawrence during the spring of 1916 and 1917.

When, in January of 1916, our scout work revealed the probable forthcoming outbreak of the canker worm, announcement was duly made and in accordance with instructions given through the press, many property owners placed bands on the elm trees and covered them with the "Tanglefoot" or other sticky substance one or more times. A few kept the bands properly renewed with the "Tanglefoot" throughout the spring, in accordance with the instructions given. The results were unsatisfactory because there were enough worms bred on the unprotected and partially protected trees to defoliate them, and also to travel from adjoining trees through interlocking branches to trees which had been properly protected.

In a letter of December 21, 1917, a prominent citizen of Topeka, Kansas, gives this point as follows:

> "My property here in Topeka is protected on two sides by fine elm trees. I have been battling to save the lives of these trees for the past three years, against the ravages of the canker worm, both by banding and spraying my trees. I have perhaps helped them a lot but still they have suffered severely and I am afraid that I am going to lose some of them. The loss of this shade to my place which faces the western summer sun, would make a Kansas summer almost unbearable and cut the value of the property in two. I am going to do everything I can to save them, but if your neighbor doesn't band his trees and look after the banding most vigilantly, it apparently does no good."

[1] W. H. Wellhouse, Bul. No. 11, Department of Entomology, University of Kansas, October, 1917. Pp. 281–315; plates I–III.

In the spring of 1917 the canker worm began to ascend the 3d of January. On the 23d of January the city commissioners ordered the elm trees banded, and the cost of the work, when done by the city, taxed to the properties. The city banded 6,000 trees and the property owners banded 5,000 trees. Due to the lateness in beginning the work, some of the under branches were defoliated by the worms whose wingless parents had ascended the trees before the bands had been put on. Not a single tree, however, that the city undertook to protect was stripped of its leaves, nor has a single one of these trees died; while in adjoining property under private protection, trees were defoliated and died and are now being used as a substitute for coal in furnaces and fireplaces.

The city renewed the "Tanglefoot" from 10 to 13 times on the trees under its protection. The cost of labor and materials was covered on a scheduled price of twenty-five, fifty, and seventy-five cents per tree for the season, depending on the size of the tree. These renewals required, likewise, the burning off of the insects on the bands, with a blow torch, before the fresh application of "Tanglefoot" could be put on. The bands were kept fresh with "Tanglefoot" until May 1. Unless the work is done thoroughly and persistently, it is possible for enough insects to cross the bands at such times as they are neglected, to make the work only partially effective.

In dealing with the canker worm in cities the use of arsenical spray is not safe, practical, or economical. The spray stains the paint on the buildings and property owners object to its use over houses where roofs drain into cisterns. The expense is many times that of banding. Chief of all, however, is the fact that much of the damage is done by the canker worm at the initial opening of the bud before it is large enough to catch the spray.

The plan of the administration under which banding was required was worked out by the city attorney. Under this plan the state entomologist was appointed city forester and instructed to have the work performed and the cost charged to the property owners, in accordance with state laws governing such work.

A mattress factory made the tar paper bands with a mixture of cotton and jute glued to the under side. These bands were handled in rolls of twenty-five feet. Many experiments with adhesive substances were made for the purpose of covering these bands. Some of these were too thin, and others were too thick, and quickly coated over. The ingredients principally used in these experimental bands were mixtures of road oil No. 7, lime, castor oil, resin, vaseline, burlap soaked in kerosene, etc. The female canker worm gave us many surprises by its strength in wading through adhesive substances. Taken altogether,

we found nothing so uniformly satisfactory as the substance known as "Tanglefoot."

The moth and the worms which hatched below the bands were captured on their way up. Those which ascended prior to the banding were captured on their way down. Just how fully we have succeeded in destroying this 1917 brood by the work of the past spring it is not possible to predict this early in 1918.

The nature of the work as conducted can probably best be illustrated from the lantern slides, which were then shown. See illustration on plates I, II and III in Bulletin, Department of Entomology, University of Kansas, No. 11, October 1917.

PRESIDENT R. A. COOLEY: Do you wish to discuss this paper?

MR. W. H. GOODWIN: I have been making some studies of the canker worm for probably sixteen years, mostly in Ohio and some of the things are interesting there. One of these is the spread of the fall canker worm. It occurs during the first three days after the canker worms hatch. They spin threads and sail away with the prevailing winds. They can spread considerable distances, I judge, at least a half mile. In some large, old orchards, bands that were put on became fifteen to twenty inches wide. I estimated that twenty trees about thirty feet high had in the neighborhood of thirty thousand females in each band. In the orchard work, spraying with arsenates was especially effective if done during the first and second instars. If they got any larger, it was practically impossible to kill them.

SECRETARY A. F. BURGESS: I am interested in this paper from a different angle. I wonder if any of us have studied the behavior of female canker worms in connection with tree banding substances. On the gipsy-moth work, we find that the tree-banding material that we used last year was satisfactory; that is, a large percentage of the caterpillars did not make any very serious attempt to cross the bands. Of course, with the canker worm the problem is different, because the females attract the males, and a considerable number of these are bound to be caught in the sticky substance, which, of course, automatically would furnish a bridge for the females to go over. I think there is a chance for some excellent work to be done in connection with the behavior of the females where bands of different kinds are used. It may be that a repellent could be used in connection with the band which would keep the females from crossing. We are doing some work along that line in connection with gipsy-moth caterpillars.

In the great apple growing section in Nova Scotia, they are having very serious trouble with canker worms. When we were making up

our tree-banding material this fall—we made up about nine tons for use next spring—a representative from the entomologist's office came down and we made up a half ton for experimental work there this fall. I am not convinced that this material is going to work out as satisfactorily on the canker worm as it does on the gipsy moth, but as a result of these experiments this will be determined. In connection with using Tanglefoot bands, we have found it very useful to comb the bands after they become hardened a little, either from excessive heat or from dew or foreign matter. We have a little wooden comb that is about three inches wide and the men comb these bands, which freshens them up and takes out a certain amount of foreign matter. By following this method, it is not necessary to re-surface the bands.

MR. S. J. HUNTER: We first tried the regular stone mason's trimming comb—a comb with fifteen teeth, but in the very beginning met difficulty with the males. We found that the torch did the work better.

Regarding the repellents, we not only wanted to find something that would keep the moth from crossing, but we wanted to find something that would kill her when she crossed. We wanted to get something in the dope that would act as an insecticide on her body. We didn't succeed. For instance, they would wade across four and five inch bands of vaseline and then lay their eggs.

MR. W. H. GOODWIN: I would think that the problem would be much more difficult in the eastern sections where we have both species of canker worms. Sometimes they go up as early as the latter part of October and some of them as late as the twelfth of April, which means that you would have to keep your bands on for a period of from four to five months.

MR. G. A. DEAN: Mr. Chairman, I had the pleasure of going over the city of Lawrence with Professor Hunter, after his work there and the part that impressed me was what can really be done when someone takes this work out of the hands of individuals and the work is done as it should be. That city was practically absolutely protected with the exception of these few places that furnish the check. It was certainly a fine piece of demonstration work.

As for repellents, I don't believe you will find that repellents will stop the female canker worm. The moth apparently will cross anything. The fall canker worm is not a serious pest with us in Kansas, and the canker worms in the orchards are easily controlled by our orchard spraying method, because the various sprays applied that control the codling moth also control the canker worm.

PRESIDENT R. A. COOLEY: If there is no further discussion, we will pass to "Notes on Fumigation of Orchids," by Mr. E. R. Sasscer and Mr. H. F. Dietz.

NOTES ON FUMIGATION OF ORCHIDS

By E. R. SASSCER and H. F. DIETZ, *Washington, D.C.*

(Withdrawn for publication elsewhere)

PRESIDENT R. A. COOLEY: Do you wish to discuss this paper or ask questions?

MR. T. J. HEADLEE: Mr. Chairman, I might inquire whether the cattelyæ fly in the orchid leaf is killed by this process.

MR. E. R. SASSCER: We haven't checked up on that. I have about reached the conclusion that we cannot kill any of these insects with plant fumigation. I would not recommend this fumigation to control any insect imbedded in the plant.

PRESIDENT R. A. COOLEY: I will call for Mr. McConnell's paper, "*Mira saltator* Lindm, as a Parasite of the Hessian Fly."

EUPELMINUS SALTATOR LINDM. AS A PARASITE OF THE HESSIAN FLY

By W. R. MCCONNELL, *Cereal and Forage Insect Investigations, U. S. Department of Agriculture*

During the course of our studies of the parasites of the Hessian fly we have reared another parasite as yet unrecorded in American literature. As is commonly the case with a parasite of an introduced insect, its determination has been a troublesome matter because of the inaccessibility of the type and the lack of properly identified representatives.

Specimens were submitted to Mr. A. B. Gahan, of the National Museum, who regarded them as identical with a parasite described from Russia by Lindemann (1) under the name *Euryscapus saltator*. He placed it in the genus *Mira*, with which *Euryscapus* has commonly been regarded as synonymous. Since the title of this paper was submitted, Mr. Gahan has studied this species further and has written regarding it as follows: "I have been fortunate enough to find in the collection here part of a specimen labelled *Euryscapus saltator* in what I believe to be Lindemann's own handwriting. It was in the box of *Pleurotropis epigonus* and other European parasites of the Hessian fly. We know that specimens of some of Lindemann's species were sent to Riley and there seems to be no reason to doubt that this broken one is authentic, whether the label is Lindemann's or not. Only the

thorax remains but this is enough to prove that the specimen was a wingless Eupelmine similar to the species in this country and not a *Mira*. What is left of the specimen agrees perfectly with your specimens, so far as I can see, so there seems to be no reason to think that the determination of our species is not correct. The name *Mira* should not be used for the genus, however, since *Mira* as now understood is not a Eupelmine." Still later Mr. Gahan wrote regarding the generic position of this parasite: "*Eupelminus* is the generic name applied to a lot of Eupelmines which are wingless or with rudimentary wings. I really do not think that this is generic but for the present it will probably be better to use the name since it does identify the species to some extent. The name to be used then will be (*Mira*) *Eupelminus saltator* Lindm."

The opinion has also been expressed by Mr. Gahan that this is the same parasite which Mr. W. J. Phillips of the Bureau of Entomology has reared from the galls of various species of *Harmolita* (*Isosoma*).

While our knowledge of this species as a parasite of the Hessian fly is by no means complete, yet it seems worth while to place upon record the fact of its occurrence in this country together with the facts we have accumulated regarding its life-history. The biological data are based on experiments conducted in the laboratory at Hagerstown, Md., chiefly during the season of 1916. The writer has been aided in the collection of material upon which the field records are based by Messrs. P. R. Myers and P. H. Hertzog. Mr. Myers has also given very valuable assistance in rearing the field puparia and has carried out some experiments on the parthenogenesis of this species.

Distribution

Lindemann's specimens were reared from puparia which he collected at Moscow and in various governments of central Russia. He states that he has never found the species abundant, but it is probably widespread in Europe, and was undoubtedly introduced into this country at an early date in infested straw. There are apparently no other records in literature.

We have reared it from the following nine localities in Pennsylvania: Carlisle, Andersonburg, State College, Danville, Montoursville, Linden, Butler, Greenville and Linesville; from Hagerstown and Braddock Heights in Maryland; and from Strasburg and Woodstock in Virginia. Mr. Phillips has reared it from *Harmolita* material from Michigan, Indiana, Ohio, New York, Pennsylvania and Virginia, and probably from other states.

The species has not been an abundant parasite of the Hessian fly during our investigations. The greatest number were found in a field

at Greenville, Pa., in 1915, where 6.67 per cent of the puparia were parasitized by it.

Hosts

Eupelminus saltator is a primary parasite of the Hessian fly, attacking externally both larval and pupal hosts inside the puparium. We have repeatedly demonstrated the primary nature of its attack by rearing it experimentally from puparia known to be free from other parasites. It may, however, become a secondary parasite of the fly, since a puparium from which an individual emerged was opened and found to be filled with cocoons of *Polygnotus*, from one of which it had issued.

Lindemann mentions that he had reared this parasite from *Harmolita hordei*. Mr. Phillips has kindly furnished a list of eight species of *Harmolita* from the galls of which he has reared it. These are *H. tritici*, *H. vaginicola*, *H. maculata*, *H. albomaculata*, and four new species of the same genus. He is certain that they have come from the galls of *Harmolita*, but is not sure whether they were primary or secondary there. There is little doubt, however, that this species is ordinarily primary, but when other parasites are abundant it can just as easily become secondary.

The Adult

This parasite belongs to the family Encyrtidæ, subfamily Eupelminæ, and can easily be distinguished from its nearest relative among Hessian fly parasites, *Eupelmus allynii* French, by its indistinct parapsidal grooves and poorly developed wings. No males are known, but the females are further distinguishable from those of *E. allynii* by their well exerted ovipositor. The wings are small and do not function. The tip of the anterior wings is bent upward at a right angle so that the apical portion is held in a vertical position; the posterior wings are shorter, very narrow, and are turned upward at the tip. While the adults are unable to fly, they are remarkably good leapers.

They normally emerge through a rounded hole near the posterior end of the puparium. Before beginning to oviposit they rest and feed for a period of two to five days, this preoviposition period probably averaging about three days. In cages they will feed on sugar solution, and they have been observed also to puncture the host with the ovipositor and feed at the wound. In one case the same puparium was punctured several times and feeding observed to take place after each puncture. This puparium, after being kept in a cage for some weeks, was found to contain a dead fly pupa, and there is little doubt that the host was killed by the feeding punctures.

When ready to oviposit the female walks back and forth over the

infested stems or stubbles with antennæ bent forward and downward and kept in constant vibration. When a suitable location is found, the abdomen is contracted longitudinally, the tip bent downward and the ovipositor pushed into the stem. If no puparium is present, the ovipositor is promptly withdrawn, but when a host is found oviposition may require several minutes. They oviposit only during daylight, and preferably during bright weather.

A female may lay as many as five eggs in a day, and probably more. She may rest from oviposition for a day or two at a time. Females have lived in cages and oviposited over a period of 3 to 24 days, and other females which never oviposited have lived as long. The maximum number of stages reared from a single female was 39, but it is necessary to make allowance for considerable mortality, and it seems probable that a female may lay at least a hundred eggs. On the other hand, some females seem to be unable to oviposit. These are small individuals which for one reason or another have had an insufficient amount of food during the larval period.

Unfertilized females are thelyotokous. Mr. P. R. Myers has reared this species through five successive parthenogenetic generations and the writer, starting with a different female, has carried them through six such generations without the appearance of a male in any case. The sixth of these generations appeared during the past summer, but the individuals were small in size and never oviposited. This was undoubtedly due to a scarcity of good host material upon which they could develop, and not to the lack of fertilization.

The Egg

The eggs (Fig. 8, 1) are deposited on the outside of the host larva or pupa inside the puparium, and cling lightly to the host. They are white in color. The chorion is thin and elastic, with a smooth and shining surface. They are ellipsoidal in form with a large pedicel at the cephalic pole and a slender flagellum at the caudal pole. They measure 0.374 mm. in length by 0.133 mm. in greatest width, taking the average of five eggs. The pedicel is about half as long as the egg and is usually folded back along the side of the egg, its tip being recurved forward, but it may be bent and twisted in various ways. The flagellum at the posterior pole is about half as long as the pedicel and usually lies against the posterior surface of the egg. It is very slender and structureless, and, as Marchal (2) has suggested for *Platygaster* and related genera, it probably results from the degeneration of the follicular cells surrounding the posterior pole of the ovarian egg.

During April and May in the laboratory the eggs hatched in about three days. In the process of hatching the larva breaks through the chorion near the base of the pedicel and slowly crawls out.

The Larva

The larva when first hatched is about 0.4 mm. long, slightly depressed, widest in the metathoracic region, and tapering to a rather acute abdomen. The head is com-

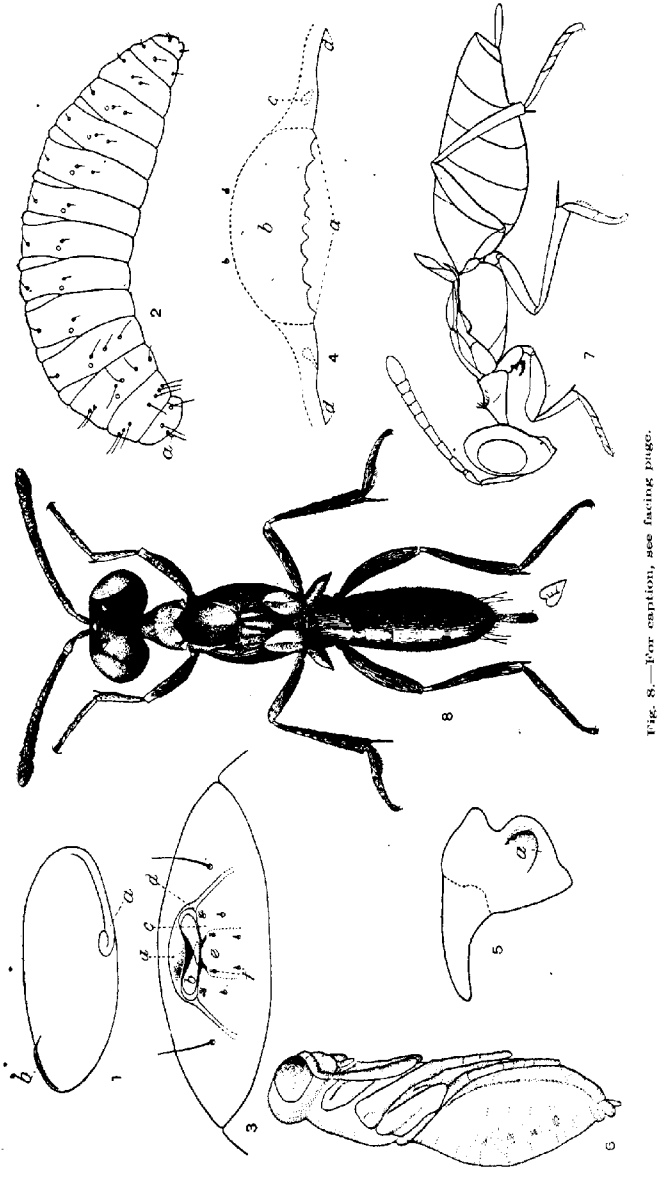


Fig. 8.—For caption, see facing page.

paratively large, convex anteriorly, and slightly narrower than the prothorax. The body color is grayish white, with very pale brownish head and large brownish black mandibles, which are simple curved hooks. The body and head are provided with long hairs, as is the mature larva.

The mature larvæ (Fig. 8, 2) vary greatly in size, but average about 2.75 mm. in length. They are white, with dark brown mandibles. The body is of the usual chalcidoid form, somewhat spindleshaped and concave ventrally. Head short, convex, without tubercles, slightly higher than wide, and partially immersed in the prothorax. Antennæ not jointed, cylindrical, with bluntly rounded apex. Mandibles simple, curved, heavily chitinized hooks, with dorsal and ventral articular processes (Fig. 8, 5). The labrum and the region dorsal to it form a concavity (Fig. 8, 3), the central part of the labrum being heavily chitinized (Fig. 8, 4, *b*) and bearing teeth on its ventral edge. These teeth are triangular and a little over 0.003 mm. long. They are irregular in number and arrangement, varying in number from 6 to 9 and are separated by interspaces usually at least as wide as the height of the teeth. The lateral regions of the labrum are very thinly chitinized and the mandibular processes (Fig. 8, 4, *c*) are difficult to see. The maxillæ (Fig. 8, 3) are thin and transparent and separated from the labium by a shallow notch. Each maxilla bears a cluster of three very small tubercles which probably represent the palpus. The labium is also thin and transparent and bears two pairs of very small tubercles probably representing the labial palpi. The head bears 8 long hairs; one pair submedian on the dorsal posterior part of the epicranium; one pair between and slightly below the level of the antennæ; another pair in the same plane posterior to the above; and a fourth pair ventral to the last and a short distance posterior to the mandibles. In addition there is a pair of small hairs dorsal to the labrum.

The body consists of the usual 13 segments. Spiracles are present on the last two thoracic and first seven abdominal segments. Prothorax with 7 pairs of long hairs; 3 dorsal, 1 lateral and 3 ventral. Mesothorax with 6 pairs of hairs: 2 dorsal, 1 lateral, and 3 ventral. Metathorax with 4 pairs of hairs: 1 dorsal, 1 lateral and 2 ventral. The thoracic hairs are all long except the dorsal metathoracic pair. Abdominal segments 1–9 each bear a pair of subdorsal hairs and a pair of lateral hairs. Segments 5–9 have in addition a pair of ventral hairs. Segment 10 bears 4 short bristles on the dorsal lobe and 2 on the ventral lobe. The abdominal hairs are all much shorter than those on the head and thorax, but increase in length on segments 8 and 9.

The young larvæ soon attach themselves to the host by means of the mandibles and use the tip of the abdomen to help anchor the body. They crawl with a leech-like movement, and when disturbed frequently retain their hold on the host by means of the mandibles and sway the body about the head as a fixed point.

EXPLANATION OF FIGURE 8)

Fig. 8, 1. Egg x 230, *a* Pedicel, *b*, Flagellum. 2. Mature larva, lateral view x 50, *a* Antenna. 3. Head of larva, ventral view x 216, *a*, Labrum, *b* Mandible, *c* Maxilla, *d* Maxillary palpus, *e* Labium, *f* Labial palpus. 4. Labrum, cephalic view x 960, *a* Toothed region, *b* Heavily chitinized concave area, *c* Mandibular process, *d* Angle of mouth. 5. Mandible, ventral view x 750, *a* Ventral articular process. 6. Pupa, lateral view x 40. 7. Adult female, dorsal view x 40. 8. Adult female, lateral view x 40. All figures have been reduced one-half. Drawings 6–8 have been made by Miss E. H. Hart.

Within two or three days after the larvæ attach themselves to the outside of the host, the latter dies, soon becomes flabby, and turns to an ashy gray color. The larva slowly absorbs the contents of the host skin, increases in size and finally nothing remains of the host but the empty skin, which is usually pushed into one end of the puparium. When the host is dead or in a partly desiccated condition at the beginning of the attack, the larva may live for a time but ultimately dies.

The larval stage requires a period of 8 to 12 days for complete development. Near the end of this stage the alimentary canal becomes completely developed and the waste material accumulated in the ventriculus is voided into one end of the puparium. In less than a day after defecation occurs the larva transforms to the pupal stage.

The Pupa

The pupa (Fig. 8, 6) is at first white, turning rather rapidly to pale reddish brown and light brown. It varies in length from 1.41 mm. to 2.50 mm., with an average for 15 individuals of 2.08 mm. The head is slightly wider than the thorax, its greatest width averaging 0.58 mm. The pupa is slightly depressed and slightly concave ventrally. The ovipositor sheath is turned upward, but does not extend dorsad of the abdomen.

The pupa stage requires 8–12 days in May and June, with an average of about 10 days. In midsummer this stage is undoubtedly shorter.

Number of Generations

In the laboratory the average time required for development from egg to adult varied greatly with the season. In May it averaged 25 days; in June, 24 days; in July, 18 days and in July–August 23 days. The shortest period of development recorded was 15 days during July. Most larvæ which develop from eggs laid during the latter part of August and September remained over winter in the condition of mature larvæ, emerging as adults the following May. The average period required for development in the overwintering generation, based on 19 individuals, was 265 days.

Five generations were reared in the laboratory in 1916 between April and September. A sixth generation overwintered, and emerged the following May. Thus it was possible to rear six generations in about a year. Under field conditions at Hagerstown, Md., hibernating larvæ were found in puparia late in the spring. Adults probably do not emerge outdoors before the middle of June at about the time puparia of the spring brood of the Hessian fly are appearing. In a season like 1916 there is time for four generations to develop during the summer, which with the hibernating generation, makes five gen-

erations a year. During a comparatively cool summer, like that of 1917, there were probably not more than three generations produced.

While up to the present time *Eupelminus saltator* has been of inconsiderable importance in the natural control of the Hessian fly, it is also true that during the time we have had it under observation there has been no extensive outbreak of either the Hessian fly or *Harmolita*. It seems probable that when either of these hosts becomes abundant, the numbers of the parasite will increase and aid in reducing the numbers of this host. In case the alternate host becomes abundant the following season, the parasites will then be ready to turn their attention to it in increased numbers and with considerable effect. It will be necessary to keep this parasite under observation for a series of years before its real value can be correctly estimated.

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PRESIDENT R. A. COOLEY: The next paper is "Grasshopper Observations, Experiments and Demonstrations in Arizona, During 1917," by Mr. A. W. Morrill.

EXPERIMENTS WITH GRASSHOPPER BAITS WITH INCIDENTAL OBSERVATIONS ON THE HABITS AND DESTRUCTIVENESS OF THE DIFFERENTIAL GRASSHOPPER (MELANOPLUS DIFFERENTIALIS)

By A. W. MORRILL, *Phoenix, Arizona*

In connection with demonstration work against grasshoppers in Arizona during the past season problems were presented which led to the series of observations and tests which form the basis of this paper. It was at first believed that one or two days' work would give the desired information but the results failed to meet expectations in this respect. Although the conclusions which may be drawn from these experiments are not as definite as desired, this paper is presented in the hope that it may be of some use during the coming season in suggesting profitable lines of work to others interested in grasshopper control as well as of some direct value as a contribution to our literature on this subject. The experimental work here reported was

TABLE I—TESTS OF GRASSHOPPER BAITS—*Concluded*

	Exper. No.	Bran	Sawdust	Molasses	Lemon	Orange	Tomato	Canteloupe	Peach	Watermelon	Paris green	Water	Grasshopper Records
Series D—July 31	65	½X	½X	X	..	..	..	X	..	..	..	X	86
	66	X	..	..	..	..	..	X	..	..	..	X	75
	67	½X	½X	..	..	..	..	X	..	..	..	X	105
	68	X	..	..	..	..	..	X	..	..	..	X	78
	69	X	..	X	..	..	..	..	..	X	..	X	88
	70	X	..	..	..	..	..	X	..	..	..	X	68
	71	X	..	..	..	..	..	..	..	X	..	X	45
	72	X	..	..	..	..	..	X	..	..	..	X	75
	73	X	..	X	..	..	..	..	..	2X	..	X	77
	74	X	..	..	..	..	..	X	..	..	..	X	53
	75	X	..	..	..	..	..	..	..	2X	..	X	57
	76	½X	½X	..	..	..	..	..	..	2X	..	X	90
Series E—August 4	77	X	..	..	..	..	..	X	..	..	..	X	37
	78	X	..	..	..	..	..	7X	..	..	..	X	54
	79	½X	½X	..	..	..	..	7X	..	..	..	X	78
	80	½X	½X	X	..	..	..	7X	..	..	..	X	66
	81	X	..	..	..	..	2X	..	..	..	..	X	35
	82	½X	½X	..	..	..	2X	..	..	..	..	X	62
	83	½X	½X	X	..	..	..	..	..	..	..	X	54
	84	X	..	..	..	X	..	..	..	..	..	X	59
	85	½X	½X	..	..	X	..	..	..	..	..	X	41
	86	½X	½X	X	..	X	..	..	..	..	..	X	57
	87	X	..	..	..	..	..	X	..	..	..	X	34
	88	X	..	..	..	..	..	..	..	10X	..	X	48
	89	½X	½X	..	..	..	..	..	..	10X	..	X	33
	90	½X	½X	..	..	..	..	..	..	10X	..	X	30
	91	X	..	..	X	..	..	..	..	..	..	X	80
	92	½X	½X	X	X	..	..	..	..	..	..	X	53
	93	½X	½X	X	X	..	..	..	..	..	..	X	43
	94	..	X	X	..	..	..	7X	..	..	..	X	28
	95	..	X	X	..	..	2X	..	..	..	..	X	18
	96	..	X	X	..	..	..	..	..	10X	..	X	28
	97	X	..	..	..	..	..	X	..	..	..	X	60
Series F—August 6	98	X	..	..	X	..	..	..	..	..	X	X	9
	99	X	..	..	X	..	..	..	..	..	X	X	49
	100	X	..	X	X	..	..	..	..	..	X	X	6
	101	½X	½X	..	X	..	..	..	..	..	X	X	14
	102	X	..	..	..	..	..	7X	..	..	X	X	12
	103	½X	½X	..	..	..	..	7X	..	..	X	X	16
	104	X	..	..	..	..	2X	..	..	..	X	X	27
	105	½X	½X	..	..	..	2X	..	..	..	X	X	11
	106	X	..	..	..	..	..	..	..	10X	X	X	18
	107	½X	½X	..	..	..	..	..	..	10X	X	X	19
	108	X	..	X	..	..	..	..	..	..	X	X	3
	109	½X	½X	X	..	..	..	..	..	..	X	X	19

Seven out of the ten records varied from the average by less than 20 per cent while three varied by between 25 and 40 per cent. The average number of the insects included in the ten records was 72 and the average variation was 11.2 or 15.5 per cent. In view of these results it is considered that there is little if any significance in differences between any two baits amounting to less than 25 per cent when the number of hoppers included in the record is less than 100. Further it is evident that even with a greater percentage of difference than 25 or with more than 100 of the insects, there is still a chance that the results from any one experiment may be misleading.

The results of the 109 experiments included in series A to F inclusive

are presented in Table I. In this table where a numeral, as ½ or 2, precedes the X a different proportion of the ingredient is indicated than is called for by what we may term the standard formula. This formula includes 25 pounds of bran, 5 lemons, 2 quarts of molasses, 1 pound of Paris green and water to make a crumbly mixture. In the molasses column, therefore, 2X indicates that the molasses was used at the rate of 4 quarts to 25 pounds of bran and in the lemon column 1½X indicates that the equivalent of 7½ lemons to 25 pounds of bran was used. Five was selected as the number of lemons for the so-called "standard formula" inasmuch as the number usually recommended is either four or six and the average appeared to be the most suitable number for the purposes of the experiments.

Fruits

In Series A, finely ground lemons, oranges, tomatoes and canteloupes were compared. The smallest number of hoppers was recorded for the lemons (47) and the highest for the canteloupe (184). The comparative rank of the four fruits are shown in Table II. In a test supplementary to Series A ground lemon and orange was exposed in watch glasses, five with each fruit alternating in a row. Five records were made of the grasshoppers found eating the fruit, the observations being at 15-minute intervals. Only 10 of the insects were recorded at the lemon while 45 were recorded at the orange.

Table II—Comparison of Fruits and Fruit Combinations, Including the Data in Series A, B, C, E and F which may Properly be Considered in this Connection

Fruit or Fruit Combination	A	B	C	E	F
Lemon	1*	1*	..	1*	1*
Orange	2	1.16	1*	.9	..
Canteloupe	4	1.18	1.85	1.13	1.15
Tomato	2.3	1.3	1.07	.8	1.9
Peach	..	1.03	..	..	..
Watermelon	..	..	..	.63	1.85

*For the purpose of comparison the unit value is given to lemon except in Series C which included no lemon combinations.

In Series B the bait combinations were used with fruits compared with lemons at the rate of 5–25, *i. e.*, 5 lemons with 25 pounds of bran. These records including 2,101 hoppers show an apparent, though no doubt negligible advantage of other fruits over lemon which is again given a valuation of 1 in the table.

In experiments numbers 36, 44 and 46 of Series C, orange, canteloupe

and tomato were used at a rate, by weight, equivalent to 10 lemons to 25 pounds of bran. In the table the orange was given the value of 1 for purposes of comparison.

In Series D will be found a comparison between canteloupe and tomato and canteloupe and watermelon. In experiments numbers 61, 63, 65 and 67 a total of 191 hoppers were recorded at canteloupe combinations and 169 at tomato combinations, a negligible difference apparently. In numbers 66 to 76, exclusive of 67, canteloupe and watermelon combinations are comparable.[1] The total hoppers recorded for the canteloupe was 339 and for the watermelon 337. .

Series E affords a comparison of canteloupe, tomato, orange, watermelon and lemon used in amounts varying according to their cost in the local market. As a matter of fact nearly every farmer in the Salt River Valley and other irrigated sections of the Southwest can secure without expense cull canteloupes, watermelons or tomatoes of good enough quality for use in grasshopper baits. The total number of hoppers recorded in the experiments which can be grouped for fruit comparisons was 870. The comparative rank is shown in Table II. It should be noted that canteloupe in three other experiments in this series, used at the 5–25 rate as a check, was unusually low, ranking as .74. This is the only instance in these experiments when canteloupe combinations did not have a somewhat better record than lemon or orange.

Series F consists of a field test on a small scale of baits containing Paris green. The mixtures were applied to areas of approximately 1/100 acre each, the fruits being used on the basis of the market value as in Series E. The records refer to the number of dead hoppers counted in each poisoned area. This, however, was found not to be a satisfactory basis for comparison since only a minority of the hoppers died within the poisoned area. As they stand the records show a total of 200 dead hoppers counted, or an average of $16\frac{2}{3}$ to each plot, the different fruit mixtures ranking as indicated in Table II. It should be noted that two other mixtures without fruit were used, bran, molasses, water and Paris green ranking as 1.1 and bran, water and Paris green as .45, the lowest of all in the Series.

In regard to the amount of fruit to be used in the poisoned bait these experiments are far from conclusive. In Series A the results showed no advantage in increasing the rate at which lemons were used from $2\frac{1}{2}$ to 5 and to $7\frac{1}{2}$ with 25 pounds of bran. With the lowest rate, No. 12, 65 hoppers were recorded at the bait while the average for two experiments at the 5–25 rate and one at the $7\frac{1}{2}$–25 rate was 67

[1] The watermelon combinations differ from those of the canteloupe in having molasses in two instances and in having a double standard amount in two instances.

hoppers. In Series C, tomato at standard rate shows 137 hoppers whereas at the double rate only 105 were recorded. Half and half bran and sawdust with orange at the standard rate has 82 hoppers recorded whereas the same mixture with the rate doubled also has 82. Canteloupe at the standard formula rate in Series D has a total of 100 grasshoppers while the same combination with the canteloupe doubled has a total of 91. When the proportion of watermelon was doubled in the same series the records show a gain from 113 to 134. In Series E multiplying the proportion of canteloupe by seven (compare 77, 87 and 97 with 78, 79 and 80) at first appears to have given appreciable results, the smaller amounts of the fruit showing a total of 131 hoppers and the large amounts 198, an increase of 51 per cent. This apparent gain is probably due for the most part to the canteloupe combination at the standard rate having an unexpectedly low record. It is evident that these experiments are of only indirect value in indicating the amount of fruits of the various kinds which can be used with advantage in grasshopper baits.

Molasses

Grouping all of the experiments in each series which can be compared with regard to molasses[1] we find the results summarized in the following table:

Table III—Comparison of Grasshopper Baits with and without Molasses

Series	No. Hoppers at Baits with Molasses	No. Hoppers at Baits without Molasses
A	182	116
B	870	924
C	433	426
D	425	384
E	196	205
F	9	49
Total	2,115	2,104

It will be noted that the baits with molasses lead three times and the baits without molasses lead three times. The difference in the totals is negligible, being less than one half of one per cent.

A comparison of citrus fruit baits with and without molasses is of special interest. Both lemon and orange baits have better records where no molasses was used, the figures being 340 and 269 for the lemon baits and 408 and 316 for the orange baits. Both citrus fruits com-

[1] The molasses known as "Black Strap" was used in all cases where indicated.

bined have a total record of 748 hoppers where no molasses was used and 588 where molasses was included.

In Series G, a bait made according to the standard formula modified by using one extra lemon and omitting the molasses, was applied to one fifth acre of alfalfa and a similar bait including molasses at the usual rate was applied to a nearby plot of the same size where the grasshoppers appeared to be equally numerous. After three days the dead hoppers were counted in a square area of 100 square yards located centrally in the fifth acre plot. A total of 234 dead hoppers were found where *no* molasses was included in the bait and only 68 in the plot where the bait contained molasses.

Owing to the movement of the adult grasshoppers after eating a fatal dose, the figures for Series F and G cannot be given full value except as evidence that the use of molasses in the baits for the differential grasshopper did not increase the effectiveness.

Sawdust[1]

A summary of the tests in which bran may be compared with pine sawdust in the several combinations shows that the sawdust was inferior to bran. For the sawdust combinations 405 hoppers were recorded whereas 781 were recorded for the corresponding bran combinations. The former therefore gave only 52 per cent efficiency as compared with the latter. When mixed with bran in half and half mixtures, however, results were obtained which were practically the same as for the straight bran combinations, the half and half mixture having 724 hoppers recorded while the bran combinations have 697 or approximately 4 per cent less.

Sawdust and Canteloupe in Field Tests

A cotton grower located near Phoenix whose crop was being damaged by the differential grasshopper, at the writer's suggestion substituted a pound of canteloupe for the lemons ordinarily used with 25 pounds of bran. The results were reported to be entirely satisfactory, the grower finding dead hoppers in large numbers while few live ones remained. The report was convincing in its detail but was not verified by the writer. On August 19 Mr. Fisk, one of the writer's assistants, poisoned a thirty-acre alfalfa field using the 4–25 bran-lemon formula[2] in comparison with two mixtures containing half and half bran and sawdust. One of these (B) was identical with the 4–25 formula except that the half and half bran and sawdust mixture was substituted for the

[1] The testing of sawdust was suggested by experiments conducted in Canada in 1915. Forty-sixth Ann. Rept. Ent. Soc. Ontario.

[2] Bran 25 lbs., lemons 4, molasses 2, Paris green 1, water as needed.

bran. The other (C) consisted of a mixture like B with one pound of canteloupe substituted for the four lemons. The standard bran-lemon formula was used in treating 5 acres. Formula B was used for treating two ten-acre sections and formula C in treating 5 acres. The number of grasshoppers per square yard varied considerably in the different sections but in the area treated with each kind of the poisoned mash there were from two to three acres where the insects varied from 15 to 50 per square yard. Four days after making the application it was estimated by Mr. Fisk that from 80 to 85 per cent of the hoppers were dead throughout the field. The results from the use of baits made with the bran-sawdust mixtures were estimated to have been fully as good as those from the standard bran-lemon formula.

In southern Arizona during the season when the differential grasshopper is most destructive, canteloupe is usually available as a substitute for the lemons. Overripe or cull canteloupes which can be obtained without cost as a rule are as good as any. Sawdust sells for ten cents a sack of about 35 pounds. The substitution of canteloupe for the lemons and of sawdust for half of the bran in the standard formula reduces the cost of the bait 20 per cent. If field tests confirm the results of the observations reported in this paper in regard to the value of molasses in bait used against the adult differential grasshopper, the elimination of molasses will reduce the cost of the bait an additional 17 per cent.

The bran available in Arizona contains a large proportion of fine material and the use of a third to a half sawdust gives a mixture which is much easier to distribute in the field. Even though the sawdust decreases the attractiveness of the mixture this disadvantage evidently would be offset by its better distribution.

Distance Poisoned Grasshoppers Travel

In testing poisoned baits it is sometimes important to know how far grasshoppers may travel after eating a fatal dose of the poison. In Series G, poisoned baits were applied in an alfalfa field to 5 plots 30 yards square. The plots were located in a row alternating with plots of equal size which were not poisoned. It was believed that by counting the dead hoppers in a square 5 yards on a side located centrally in each of the poisoned plots the effectiveness of the baits could be determined. This method proved a complete failure and consequently a second count was made within a square plot 10 yards on a side. In the 5 plots the smaller squares (5 x 5 yards) averaged 23 dead hoppers or an average of a little less than one per square yard. Contrary to expectations the space between the inner squares and the boundaries of the larger squares (10 x 10 yards) averaged 1.3 dead

hoppers per square yard. There was a very striking migration of poisoned hoppers from the poisoned plots toward eucalyptus and cottonwood trees forming a broken row along one side of the field. The poisoned plot at the south end of the row had a total of 234 dead hoppers in the 100 square yards of space above mentioned. Beneath a tree standing in the southeast corner of this plot 364 dead hoppers were counted. Due south of this tree were four others, 31, 54, 66 and 78 yards distant respectively. Eight poisoned hoppers were found beneath the first, three beneath the second and three beneath the third. None were found near the tree which was 78 yards distant from the poisoned plot. In another experiment where there were no trees to attract the poisoned grasshoppers, 40 of the dead insects were counted in a poisoned plot 7 yards square. Within 10 yards north of the north border there were 20 dead hoppers, between 10 and 20 yards there were 14 dead hoppers, between 20 and 30 yards 12 dead hoppers. None were found more than $27\frac{1}{2}$ yards from the poisoned plot.

Relation of Time of Day to Feeding of Adult Grasshoppers

In the course of the bait tests reported in this paper records were secured which tend to show that in alfalfa fields the adult differential grasshoppers feed most actively during the warmer parts of the day and less actively toward night. By segregating the records which began at 3 p. m. and extended to 6.45 the following table has been arranged:

Table IV—Relation of Time of Day to Feeding of Grasshoppers*

Date	Exp. Series	3–3.45	4–4.45	5–5.45	6–6.45
July 27	B	128	84	56	21
July 30	C	150	143	58	43
July 31	D	68	50	37	18
Average		115.3	92.6	50.3	27.3
Per cent		40.4	30.3	17.6	9.5

* The figures represent the average of four observations taken on the hour and quarter hours.

The total number of hoppers included in the records was 3,382. These records are entirely incidental and it should be said that no effort was made to determine definitely whether the attractiveness of the baits in the pans remained constant throughout the periods when the records were made. It is the writer's opinion, however, based on general observations, that decreasing attractiveness of the baits was not an important factor in the results.

In demonstration work one of the most effective applications of bran mash which the writer has ever observed was put out in a cotton field on July 3, 1917, between seven and eight o'clock in the morning. We have usually recommended that the bait be put out as soon after daybreak as possible and in general our observations in Arizona show better results from early morning applications than from applications made late in the afternoon. The data summarized in the foregoing table suggests that bait for the differential grasshopper may be spread with good results during the warmer part of the day up to 3 or 3.30 p. m. Working with another species of grasshopper (*Eucoptolophus subgracilis* Caudell) near Yuma, Arizona, on October 20, 1917, and a few days following, Mr. J. L. E. Lauderdale reports good results in killing the hoppers with bran mash applied between 3 and 3.30 p. m.

Amount of Alfalfa Consumed by Grasshoppers

There are times when farmers hesitate to spend forty or fifty cents an acre for materials with which to poison grasshoppers. In our work in Arizona a need was felt for a definite basis for estimating the daily damage done by these pests. Consequently two tests were conducted (July 18–20, 1917) with adult specimens of the differential grasshopper in order to determine the capacity of this species for destroying alfalfa.

In the first test 50 adult specimens were used. A lot of freshly cut alfalfa weighing eight ounces, with stems in a bottle of water, was placed in a wire screen cage containing the grasshoppers and a check lot of alfalfa was placed in a nearby cage. Twenty-four hours later only 37 of the 50 insects could be found in the cage. The two lots of alfalfa were weighed and the amount of green alfalfa destroyed by the hoppers was computed. It was found that the check had decreased 18.2 per cent in weight while the lot on which the insects fed decreased 38.8 per cent. The net difference in weight was 44.87 grams. Assuming that the 13 missing specimens averaged twelve hours in the cage before escaping, the average amount of green alfalfa destroyed by the hoppers was approximately one gram. Of this about $6\frac{2}{3}$ milligrams consisted in leaves and tender stems which were severed and had dropped to the ground. At this rate an average of 7.56 adult hoppers per square yard would be capable of consuming green alfalfa which would be equivalent to 1/100 of a ton of alfalfa hay per acre or one ton for 100 acres.

In the second test 25 adult specimens were used and as all were accounted for at the end of twenty-four hours the data obtained is more satisfactory than in the first test. The amount of green alfalfa destroyed averaged 1 2/5 grams for each insect. At this rate an average of 6.3 adult hoppers per square yard would destroy green alfalfa

equivalent to 1/100 ton of hay. Using this as a basis we may figure that an average of one hopper per square yard may destroy the equivalent of three pounds of alfalfa hay per acre per day. In a forty-acre field a moderate infestation averaging 16⅔ hoppers per yard may destroy the equivalent of one ton of alfalfa hay per day. We may also figure that at present market values for alfalfa hay in Arizona, the cost of using poison bait is considerably less than the damage done in a single day by adult differential grasshoppers occurring at the rate of 16⅔ per square yard. It is evidently very profitable to poison the hoppers even when they average as few as 5 per square yard.

It is unnecessary to say that calculations of this kind prove very effective in connection with demonstration work in grasshopper control, particularly when the infestations are not conspicuously heavy.

PRESIDENT R. A. COOLEY: Do you wish to ask Dr. Morrill any questions or to discuss this contribution?

The points covered by Dr. Morrill are certainly of much interest and very valuable in practical work in the field among farmers. We learned that this past season in our grasshopper experiences. I am particularly glad that this work was undertaken.

The next paper is by Mr. W. P. Flint, of Illinois—"A New Method of Combating the Chinch-Bug."

SUGGESTIONS FOR A NEW METHOD OF DESTROYING CHINCH-BUGS

By WESLEY P. FLINT, *Assistant, State Entomological Survey*

This paper is given not with the idea of showing the results of a finished series of experiments, but as suggesting a possible new point of attack on one of our most destructive grain insects.

During field operations against the chinch-bug in Illinois, when immense numbers of these insects had been confined for some days in dry stubble fields, it was noticed that they would collect in large numbers on any moist object or on the ground where water had been spilled. A close examination of a large number of chinch-bugs that were gathered on a moist gunny sack used to protect a water jug showed that nearly all had their beaks inserted in the sack and were apparently sucking the water from it. From these observations it seemed possible that chinch-bugs might be killed if they could be induced to feed on some substance which was moistened with water containing some soluble poison.

During the winter a number of experiments were made in which adult chinch-bugs taken from their hibernating quarters were placed in large open boxes in the laboratory. The sides of these boxes were chalked to prevent the escape of the bugs, and small masses of bran wet with a solution of sodium arsenite at different strengths were placed in some of the boxes, and bran and water in others. The results of these experiments proved that at moderately high temperatures the bugs would collect on the bran and suck the moisture from it. A very high percentage of those in the boxes containing the bran wet with the sodium arsenite died in a few hours, while those in the checks lived for a number of days. Attempts to make the bran more attractive to the bugs by adding corn syrup to the solutions were without results.

During the spring of 1917, further experiments along this line were made in the field. A wheat-field of about fourteen acres, moderately infested with chinch-bugs, was selected for this work. As soon as the wheat was cut, a barrier was made around the field by cleaning a narrow strip of all vegetation and pouring on this a line of crude creosote. A number of substances wet with solutions of sodium arsenite, lead acetate, and sodium cyanide at strengths of from $\frac{1}{2}$ ounce to 2 ounces per gallon of water, were placed along the inside of this barrier, where large numbers of bugs were sure to come in contact with them.

The solutions of sodium arsenite were not found very effective at any of the strengths tried. This substance in solution seemed to have a slightly repellent effect on the chinch-bugs.

Solutions of sodium cyanide were effective in killing large numbers of chinch-bugs, but more from the effect of the fumes than as a stomach poison. Such solutions would be too dangerous to handle to recommend for general use.

Solutions of lead acetate at 2 ounces to 1 gallon of water proved the best of any of the poisons tested. Fresh corn stalks cut and dried for several days were soaked in a solution of lead acetate at the above strength, spread along the ground just inside the barrier, and covered lightly with straw to prevent rapid drying. After twenty-four hours there was an average of 104 dead chinch-bugs to the square inch under this material. The dead bugs were removed each morning, but the stalks were not wet with the poison solution for seven days. On the sixth day there was an average of 11 dead bugs to the square inch under this line. This experiment was repeated five times with approximately the same results. A solution of lead acetate at 2 ounces to 1 gallon of water was placed in a mason jar sunk in the ground, and a wide lamp wick, twenty-four inches long with one end in the solution, was laid along the ground and lightly covered with straw. It was only possible to keep this wet for about twelve to sixteen inches.

After twenty-four hours 603 dead chinch-bugs were counted in a space two inches square on and beside this wick. This remained effective as long as the wick was kept moist and the weather continued dry. Rains had the effect of greatly lessening the number of bugs killed.

A device sold generally for poisoning flies, known as "The Daisy Fly-killer," and containing "metallic arsenic," according to the label, was placed on the ground near the barrier and lightly covered with straw. This apparatus consisted of a shallow tin box about three inches one way by two the other, with a number of perforations in the top through which insects could get access to the poison solution which it contained. It was kept in place for six days, and an average of 300 dead chinch-bugs per day were found on and immediately around it.

Attempts to make the solution of lead acetate more attractive to the chinch-bugs by adding the juice of freshly crushed corn stalks, were without results. Bran, corn silage, the very dry refuse corn stalks from the feed lot, wheat straw, and weeds, were all tried as carriers for the poison solutions. Only the corn silage and bran proved of any value, and these were not as attractive to the bugs as the freshly cut and dried corn stalks.

Although these experiments have not been carried to a point where any of the facts learned from them can be applied in field practice in combating the chinch-bug, and possibly no such application can be made, they have at least shown that it is possible to kill chinch-bugs in large numbers by the use of soluble poisons, and may prove of value in our fight against this insect.

URBANA, ILLINOIS,
December 18, 1917.

Adjournment.

Afternoon Session, Wednesday, January 2, 1918, 1.20 p. m.

PRESIDENT R. A. COOLEY: We will take up the next number on the program, which is "Some Results of Two Years' Investigations of *Dermacentor venustus* Banks in Eastern Montana," by Mr. Parker, of Montana.

SOME RESULTS OF TWO YEARS' INVESTIGATIONS OF THE ROCKY MOUNTAIN SPOTTED FEVER TICK IN EASTERN MONTANA[1]

By R. R. PARKER, *Bozeman, Mont.*

Until 1915 the occurrence of Rocky Mountain spotted fever in eastern Montana was thought to be limited to Carbon County. Though this is now known to be untrue, still the spring of 1915 was the first in which the disease was sufficiently prevalent to attract marked attention. The infected territory included most of the eastern counties, particularly the central and southern. So many cases appeared and in such a large area that a brief survey of conditions was undertaken. The need for extensive research was immediately apparent. Intensive studies were carried on at Powderville in southern Custer County in 1916 and at Musselshell in Musselshell County in 1917, infection having existed at both localities. Trips to other localities and correspondence have increased the comprehensiveness of the work.

The character of the country was found to have a fundamental influence on the abundance of ticks and a brief statement of conditions is necessary before proceeding. Though there is some variation, the greater part of the country conforms to two types,—the prairie type and the hill type. In the former the country is very bare, sage brush and prairie grasses the predominant plant life, while tree growth is mainly confined to the river banks. The Powderville studies were carried on in this sort of country. The work at Musselshell, however, was in the hill type. There the formation consisted of hilly, pine-wooded areas separated by narrow valleys, from which much narrower, many branched coulees extended far back into the hills. The valleys and hills were joined by very steep, rocky slopes, that were frequently wooded.

ABUNDANCE OF TICKS.—One of the first observations of importance was that in most regions ticks are really numerous only during occasional seasons. The year of 1915 was one of great abundance in many places. Occasional areas are found included in the prairie type, however, where ticks are either abundant each year or at least at more frequent intervals than on the prairie itself. Such areas are usually small and the difference in the abundance of ticks is due to changes in the fauna dependent on highly localized changes in the vegetation. A good example is furnished by the U-shaped bends of the Powder river where the enclosed land frequently is heavily wooded and there

[1]Contribution from the Montana State Board of Entomology.

is abundant underbrush. Such places are exceedingly favorable for the increase of certain species of tick hosts, which, under prairie conditions, are never numerous enough to be of importance.

WILD MAMMALS AS TICK HOSTS.—The conclusions regarding the importance of various wild mammals as tick hosts are based on the examination of 1,703 animals belonging to about 30 species. Under prairie conditions 11 species were found to be hosts of larval and nymphal ticks. These were jack rabbits, cottontail rabbits, deer mice, field mice, chipmunks, pack rats, kangaroo rats, striped spermophiles, grasshopper mice, prairie dogs and porcupines. Porcupines, grasshopper mice and probably prairie dogs are of little importance. On the other hand, in the hill country at Musselshell, where the country was rocky and more or less wooded, deer mice and chipmunks were the only generally distributed hosts of the immature ticks that were of any importance. Rabbits and pack rats, normally rather numerous, were very scarce in 1917, but would be factors to be reckoned with whenever abundant. Field mice were important wherever conditions favored their presence in large numbers.

As hosts of the adult ticks wild mammals were found to furnish three,—jack rabbits, porcupines and coyotes. The importance of coyotes is uncertain.

Of the animals above mentioned, jack rabbits, porcupines, deer mice and field mice are deserving of further discussion.

Jack Rabbits.—The jack rabbit merits distinction as the most important wild mammal of eastern Montana in relation to the spotted fever tick. This is due to the following reasons: first, it is the only animal known to harbor all three stages of the tick; second, according to all indications it can maintain an infestation of ticks without the presence of domestic animals; third, it is generally distributed in all parts of eastern Montana; fourth, it has a wide travelling radius; fifth, it is susceptible to Rocky Mountain spotted fever[1]; sixth, there is reason to believe that this rabbit may play an important part in the spread of the disease both extensively and intensively.

Under prairie conditions, when ticks were not at all abundant, 65 of 84 jack rabbits examined were tick infested (77.38 per cent). Fifty-six (66.66 per cent) were infested with adults. This was an average of 1.87 adults per rabbit, whereas the average for horses examined during the same period was 1.44. The greater percentage of females on horse, however, would probably more than discount the numerical superiority in favor of the rabbit, and in years of real tick abundance

[1] This has been demonstrated by work recently carried on at the Harvard Medical School under the direction of Dr. S. B. Wolbach, who has lately contributed greatly to the knowledge of the etiology and the pathology of the disease.

the horses would undoubtedly show the higher average. Jack rabbits are especially efficient as nymphal hosts, the latter engorging in much less time than on any other animal and may be present in large numbers. Cottontail rabbits are also important, but principally as hosts of the immature stages; and it is likely that they are susceptible to the disease.

Interesting observations of the past two seasons have pointed to a frequent coincidence of the abundance of ticks and the abundance of jack rabbits preceding the occurrence of cases of the fever. It is well known that in many regions rabbits will suddenly increase greatly after several years of relative scarcity and then after a few years of abundance will as suddenly die off, due to causes not well understood. The intervals between the epidemics are variable but seven years has frequently been recorded, though it may be more or less. At Powderville rabbits reached their maximum abundance in 1914 and died off in great numbers during the winter of 1914 to 1915 and for some time thereafter. The latter year was that of great tick abundance and also that in which several cases of fever occurred in that region. It is not desired to direct attention to the possible influence of rabbits on the periodical abundance of ticks, however important that may be, but rather to point out that a periodic increase in rabbits means a periodic increase in an animal highly susceptible to spotted fever, and when it so happens that an increase in ticks is coincident, it is reasonable to suppose that if infection is present in nature, then a considerable increase in the number of infected ticks becomes possible. The occurrence of fever following a parallel increase in rabbits and ticks, therefore becomes of interest. The data indicate the possible control of spotted fever under eastern Montana prairie conditions by the eradication of rabbits: conclusive evidence will be sought in our future field operations.

Porcupines.—Several of these animals examined under prairie conditions late in the season of 1916 were infested with adult ticks, one a fully engorged female. The likelihood that they might be important adult hosts has since been strengthened by emphatic statements by ranchers and further observations. More than 20 adult ticks have been found on a single animal and a seasonal average of 6.8 was obtained in 1917. Where numerous these animals are surely of some importance.

Deer Mice.—Next to the jack rabbit, the deer mouse is certainly the most important wild mammal in eastern Montana, considered as a whole, in relation to the tick. The reasons for this are,—first, it far exceeds in abundance all other wild mammal hosts of immature ticks combined, second, its wide distribution and its adaptability to all

sorts of conditions, third, the fact that it is a most efficient host of larvæ and nymphs. The degree to which these mice are infested depends largely on the combination of conditions present in any locality. Every variation may be found from the locality where an infested mouse is a rarity to that in which all are infested. For example, in the Musselshell operations, 54 mice taken on a certain homestead at various times during the season were all uninfested, whereas 9 mice taken in a badly infested coulee on August 5 averaged 19.88 ticks each, and 5 taken in a similar location on August 23 averaged 19.40. As many as 125 ticks have been taken from a single mouse, 39 of them fully engorged. The average infestation for 307 mice taken under prairie conditions was .19 (in a poor tick season), that for 343 mice under hill conditions 1.25. In prairie country these mice were found in every conceivable sort of place, while under the hill conditions studied they were abundant only on the rocky slopes along the edges of the valleys.

Field Mice.—The possible importance of field mice was suggested by the work on the prairie where the average infestation was found the same as for deer mice. Under hill conditions more definite data were secured. For 26 mice examined during 1917 the average of larvæ and nymphs was 5.15. The average for 9 taken from a badly infested coulee on August 5 was 10.73. The high seasonal average in 1917 does not mean that they are in any way comparable to deer mice as hosts. They are not. It is only where very favorable habitat conditions occur, and this is not frequent, that they are of importance. Where this is the case, however, they are a factor to be reckoned with.

One may easily be deceived as to the importance of mice unless great care is used. Suspecting that such was the case observations were made which showed that the great majority of deer mice get into traps before 11 o'clock at night and most field mice much earlier. The ticks are therefore afforded ample time to leave the host even though the traps are collected early in the morning. The precaution of examining the ground around each trap has not only greatly increased the value of our records, but has also made it evident that the figures given are too low.

As to domestic animals as hosts of adult ticks there is little of definite value to add to the facts learned in the Bitter Root. There is some difference in habits as regards the points of attachment to the host. It was discovered, however, that pigs running at large will pick up large numbers of ticks, a fact of some interest. Tabulation of data for 1917 shows that horses, cattle and pigs are efficient as tick hosts in the order named. The records show that of the ticks taken from

these animals in the order given, the per cent of females showing engorgement was 74.42, 60.93 and 24.61; the per cent over .5 engorged was 3.86, 1.75 and 0 (average per animal .29, .11, .00); and the per cent over .8 engorged was 2.70, 1.46 and 0 (average per animal .29, .20 and 0). No females more than .2 engorged were found on pigs.

It is of interest to compare some of the facts given above with those which govern the control system used in the Bitter Root Valley. Control there is dependent on the facts that adult ticks are essentially confined to domestic animals and that the Columbian ground squirrel is by far the most important small mammal as host of larval and nymphal ticks. In eastern Montana, on the other hand, the adults are not confined to domestic animals but the jack rabbit is also an exceedingly important host, with the porcupine as an able accessory. Also instead of one small and easily controlled mammal as the most important host of the young ticks, we find several efficient hosts, their relative importance frequently depending on local conditions. Mice, seemingly of scant importance in the Bitter Root, are one of the important problems in the east.

Relation of the Character of the Country to the Abundance of Host Animals and of Ticks.—A thorough comprehension of the tick problem in eastern Montana, and probably in many other places where the milder type of the fever occurs, involves an accurate knowledge of the effect which the character of the ground and the floral setting has on the abundance of the tick, and the reasons therefor. Other factors being favorable, the abundance of ticks depends to a large extent on the character of the ground, whether rocky or clear, and upon the nature of the vegetation. It is these factors which determine the species of host animals and their *relative* abundance. For example, in a prairie country, only prairie animals, of which the jack rabbit is one, can become really numerous, while species such as the chipmunk that are not adapted to such conditions can never become sufficiently numerous to be a real factor in tick abundance. Another example is furnished by the conditions existing in the hill country. There the ticks were found largely confined to the rocky slopes between the valleys and the hills and in the coulees. This was because it was in these places that the deer mice and chipmunks, previously mentioned as the important hosts of that region, found the most favorable habitat conditions. Whenever ticks were numerous under other conditions it was explainable by the presence of other host animals adapted thereto. Mention has already been made of the fact that field mice were of importance only where conditions particularly favored them. It has also been found that certain animals which, under prairie conditions, are found both in rocky places and in rock free areas, always

yield the most ticks when taken in the rocky situations. These facts are interesting and important.

The writer wishes to acknowledge the valuable aid of his assistant, Mr. R. W. Wells, in conducting the studies upon which this paper is based.

PRESIDENT R. A. COOLEY: This paper is before you. Do you wish to ask questions or make contributions on the same subject?

MR. F. C. BISHOPP: Dr. Parker's discoveries in eastern Montana are exceedingly interesting to me. I believe probably the most important bearing is that the facts he has found out there will be more or less applicable to the large area of the country infested by the spotted fever tick and where the disease occurs, notably: Idaho, Nevada, parts of California and I might say parts of Montana and Colorado.

The work that has been done heretofore, as you probably know, has been confined largely to eastern Montana, where we have a special set of conditions and control matters worked out there are very clearly, as shown by Dr. Parker, not entirely applicable to conditions elsewhere in the West.

We have examined a good many jack-rabbits in different parts of the country and our experience has been that we seldom, if ever, find the female tick and it is our opinion that most of the ticks are dislodged on the jack-rabbits before they become full grown.

MR. R. R. PARKER: We found them more or less on horses.

PRESIDENT R. A. COOLEY: Is there any further discussion? If not, we will call upon Mr. Wood for his paper on "Sodium Fluoride—A Specific for Biting Lice."

SODIUM FLUORIDE—A SPECIFIC FOR BITING LICE

By F. C. BISHOPP and H. P. WOOD, *Dallas, Tex.*

(Withdrawn for publication elsewhere)

PRESIDENT R. A. COOLEY: Is there any discussion? If not, we will pass on to the next paper, "Mosquito Flight as a Factor in the Problem of Control," by Mr. Headlee, of New Brunswick, New Jersey.

MOSQUITO FLIGHT AS A FACTOR IN THE PROBLEM OF CONTROL

By T. J. HEADLEE, *New Brunswick, N. J.*

(Withdrawn for publication elsewhere)

PRESIDENT R. A. COOLEY: Do you wish to ask Dr. Headlee any questions or to discuss this paper?

It has been of particular interest to me to listen to this paper, because we are beginning to undertake mosquito work in Montana and the problem of migration is particularly acute in that state.

I believe there are some interesting points in the paper which Professor Cockerell sent on and the Secretary is going to review one or two of them.

THE MOSQUITOES OF COLORADO

By T. D. A. COCKERELL, *University of Colorado*

More than a dozen years ago, when I was resident at Las Vegas, New Mexico, a prominent army medical officer appeared in town, to investigate the neighborhood as a possible site for a camp to which soldiers from the Philippines or the West Indies might be sent. The local merchants, always keen to extend their trade, wished to do everything possible to encourage the project. The officer, however, asked to see an entomologist, who might inform him whether *Anopheles* existed in the vicinity. I was accordingly called in, and testified that while I had met with *Anopheles* in the southern part of New Mexico, I had never seen any about Las Vegas. Scarcely had the officer departed, when I found *Anopheles* larvæ almost under the windows of the big sanitarium at Las Vegas Hot Springs. It was of course my duty to inform the army authorities, but I was rather relieved to hear that before my letter came it had been decided on quite other grounds not to place the camp at Las Vegas. The *Anopheles* was bred, and proved to be *A. pseudopunctipennis* Theob., quite new to that part of the world.

This year the same general problem presented itself in another form. In the course of the war, it will be necessary to establish a number of recuperation camps, and of course these must be situated in the most favorable localities. On account of frequent infection with tuberculosis, the drier regions of the west will prove especially beneficial. The malaria problem will be less important, but the absence of *Anopheles* is to be desired, to say the least. It will also be very desirable to place the camps reasonably close to commercial centers of distribution, so that food and other materials may be obtained without undue cost. On all these counts eastern Colorado, with portions of adjacent states, may be especially recommended. I mapped the recorded distribution of *Anopheles* from the data in the great work of Howard, Dyar and Knab, and found that the genus existed practically all over the United States, excepting apparently an area including eastern Colorado,

Wyoming, Nebraska, the Dakotas, and some adjacent regions. It is not probable that *Anopheles* is actually absent from all this area, but even if locally present it can often be readily exterminated, owing to the limited possible breeding places. It was obvious, however, that our knowledge was extremely incomplete, and it seemed desirable to determine the actual facts relating not merely to *Anopheles*, but to the Culicidæ of the region generally. With this purpose in view, a mosquito survey of Colorado was begun this year. It was also planned to include Wyoming, from which it appeared that only one species (*Aedes nigromaculis*) was recorded, and collections were made in several localities. I recently learned, however, that Dr. John W. Scott and Mr. O'Roke of the University of Wyoming had taken up the Culicidæ of their state, and consequently we shall restrict ourselves to Colorado, merely presenting below the few Wyoming records already obtained. So far as recorded by Howard, Dyar and Knab, the Culicidæ of Colorado number seven species, referable to *Anopheles*, *Culex*, *Aedes* and *Theobaldia*. The material came from nine localities. Our own collections, prior to 1917, were of little value. During the past summer Professor Junius Henderson of the University of Colorado made two long trips in a Ford car, the first in Colorado, the second in Wyoming. On these journeys Culicidæ were collected whenever possible, and the collections thus obtained greatly extend our knowledge of distribution. The localities represented are as follows:

(A.) Colorado (J. Henderson and P. Andrews).

(1) *Eastern slope.*

(a) Pueblo County. One mile east of Avondale, June 27; Boone, 4,477 ft. alt., June 28.

(b) Chaffee County. River bottom 3 miles southwest of Salida, July 1; S. Cottonwood Canyon, west of Buena Vista, 8,500 ft., July 4.

(c) Lake County. Upper Twin Lake, about 9,020 ft., July 5; two miles south of Leadville Junction, July 6. Seven miles south of Leadville, at 9,300 ft., July 8, *Prosimulium fulvum* (Coq.) was taken.

(2) *Western slope.*

(a) Eagle County. Two miles west of Tennessee Pass, July 9; four miles above Red Cliff, 8,850 ft., July 12; Cataract Creek, east fork of Eagle River, above Minturn, July 9; two miles above Minturn, at mouth of Cross Creek, July 14; four miles above Pando, east fork of Eagle River, July 10 (larvæ and pupæ); Wolcott, 6,965 ft., August 2; six miles above Wolcott, July 16; McCoy, August 4; creek

between Gypsum and Glenwood Springs, via Cottonwood Pass road, July 16.

(b) Pitkin County. One mile southwest of Aspen, July 22; Crystal River, one mile above Red Stone, July 27.

(c) Garfield County. Three or four miles above Carbondale, July 19; 13 miles above Glenwood Springs, on Grand River, August 2; 2½ miles north of Rifle, July 25.

(B.) WYOMING (J. Henderson and E. Schwabe).

(a) Bottom lands at Basin, August 29. *Aedes nigromaculis*, *A. curriei* and *A. vexans*.

(b) Box Elder Creek, 19 miles west of Douglas, August 25.

(c) Shell Creek, five miles above Shell, September 2. *Aedes vexans*.

(d) Dry mesa three miles north of Ten Sleep, August 28; Creek bottom three miles east of Ten Sleep.

(e) North Platte Bridge, about 8 miles northeast of Wheatland, August 24. *Aedes* in bad condition; one at least is *curriei*, some seem to be *vexans*.

On September 6, Dr. Chas. N. Meader kindly took me in his car to visit the localities occupied by troops in the vicinity of Denver. The following were examined with some care:

(a) Camp Baldwin. Could not find any species breeding, but in a dried up marsh, among tall reeds, were great quantities of mosquitoes. We caught ten females, and all were *Aedes vexans* (*sylvestris*), which did its best to justify its name.

(b) Fort Logan. Examined all pools by the river and pond near Fort, and obtained no culicids, larvæ or adults. The weather had been extremely dry, and the river had fallen, leaving many small pools, which were, however, full of fishes and frogs. We later learned that the pools about the camp had been oiled "every now and then" by the military authorities, but on September 6 we found little evidence of oil.

(c) Rifle range, near Golden. Could not find any species breeding. Caught a ♀ *Aedes vexans* and a male *Culex tarsalis*.

Our general impression was that Culicidæ were relatively scarce in the region, and where they occurred, they could very easily be dealt with. Another species, *Theobaldia inornata*, has been taken by Tucker at Denver.

Other collections were made at Boulder, Longmont and Brainerd Lake in Boulder County. On September 9 my wife and I examined Boulder Canyon from the mouth upward a distance of over three miles. The creek had fallen recently, and small pools were left, with very young fish in them. No culicids were found breeding, nor were

any adults caught. Cattle at the mouth of the canyon had no culicids on them, but were plentifully infested by the horn-fly, *Hæmatobia serrata*.

The species so far definitely identified from Colorado or Wyoming are the following:

(1) *Anopheles quadrimaculatus* Say. Recorded only from the far western part of the state, at Hotchkiss and Delta in Delta County, where it was taken by G. P. Weldon, as is recorded by Howard, Dyar and Knab. We have so far found no trace of *Anopheles* in our collections. In the vicinity of Grand Junction, which is still nearer the western border, E. P. Taylor obtained four species of Culicidæ, but they were *Theobaldia incidens*, *Culex tarsalis*, *Aedes curriei* and *A. vexans*.

(2) *Culex tarsalis* Coq. Common at low altitudes, up to about 6,000 ft., but not in the high mountains. It is particularly abundant at Boulder, coming into the University buildings. It is the only mosquito at present recorded from Colorado Springs.

(3) *Culex pipiens* L. Recorded from Denver by Tucker in 1907, but the record needs confirmation. It was supposed to have been determined by Dyar, but Mr. Knab states that the determination must have been by Coquillett.

(4) *Theobaldia inornata* Willist. Common at Boulder; also collected at Denver and Florissant, and by Philip Andrews at mouth of Cross Creek, two miles above Minturn. The altitudinal range in Colorado is about 5,000–9,800 ft., so far as ascertained.

(5) *Theobaldia incidens* Thoms. Recorded from Grand Junction (E. P. Taylor), and Henderson and Andrews took it in S. Cottonwood Cañon, near Buena Vista. It is decidedly less common with us than *T. inornata*, and seems not to go so high in the mountains.

(6) *Aedes acrophilus* Dyar. Dr. Dyar has determined this from females and larvæ; the male is unknown. I had regarded the species as a new one near *pullatus*, but at the time the description of *acrophilus* (Ins. Ins. Mens. 1917, p. 127) from Alberta was being printed. Our localities are: females from a mile southwest of Aspen; S. Cottonwood Cañon, near Buena Vista; Cataract Creek, near Minturn; two miles west of Tennessee Pass. Larvæ from four miles above Pando, East Fork of Eagle River, July 10 (P. Andrews). It is a mountain species in Colorado, belonging especially to the Canadian Zone.

(7) *Aedes aldrichi* Dyar & Knab. Boulder (Cockerell); I determined it as *aldrichi*, and Dr. Dyar agrees.

(8) *Aedes cinereus* Meigen. One female taken by Schwalbe and Henderson at Box Elder Creek, 19 miles west of Douglas, Wyoming. I took it for a new species, on account of the bright ferruginous thorax, with three very faint dorsal dusky stripes. Very possibly it represents a subspecies, but more material is needed. Dr. Dyar assures me that it has entirely the structure of *cinereus*, and cannot possibly represent a distinct species.

(9) *Aedes curriei* Coquillett. Common at lower altitudes in Colorado. Recorded from Grand Junction and Florissant, I have it from Boone, Boulder (it occurs on the University Campus), Grand R. above Glenwood Springs, Longmont, 2½ miles north of Rifle, and Wolcott. The specimens from Wolcott and thirteen miles above Greenwood Springs have very handsome markings, and represent the variety *mediolineata* Ludlow. In Wyoming *curriei* was taken in the bottom lands at Basin, and at the North Platte Bridge near Wheat-

land; var. *mediolineata* comes from the dry mesa three miles north of Ten Sleep. On the dry mesa near Ten Sleep the catch was 6 *curriei mediolineata* and one *vexans*, but in the creek bottom 7 *vexans* only. *A. curriei* goes to about 8,000 feet in dry localities, as at Florissant, but is absent from the Canadian zone.

(10) *Aedes idahoensis* Theob. Our form, referred to *idahoensis* by Dr. Dyar, has the abdomen banded, and looks distinct from the more typical form, with square black patches on abdomen, collected by Dyar in Montana. As we have neither males nor larvæ of the Colorado insect, the determination may be subject to revision. The localities are: three miles south west of Salida; one mile south west of Aspen; creek between Gypsum and Glenwood Springs (a small specimen); Upper Twin Lake; six miles above Wolcott; 3 or 4 miles above Carbondale; McCoy; two miles above Minturn. Several specimens from different places were examined by Dr. Dyar, and the others seem to me to be identical. I had first regarded the species as *A. hirsuteron*, which is very close to *idahoensis*, but the wing scales are not all black. In Colorado, *idahoensis* is of the Transition and Canadian zones.

(11) *Aedes mimesis* Dyar. I had regarded this as a new species; Dr. Dyar refers it to *mimesis*, described from Montana and British Columbia in Ins. Ins. Mens., 1917, p. 116. It comes from Upper Twin Lake, and four miles above Red Cliff (alt. 8,850 ft.); it is therefore a species of the higher mountains. There is a broad median brown band on thorax, in *curriei* style. The markings of the abdomen are variable.

(12) *Aedes nigromaculis* Ludlow. A species of the plains; recorded from Akron and Boulder. In Wyoming Henderson and Schwabe took it at Basin.

(13) *Aedes pullatus* Coquillett. A male which I collected at Estes Park Village (6,810 ft.), June 24, has been kindly examined by Dr. Dyar and found to be genuine *pullatus*.

(14) *Aedes sansoni* Dyar & Knab. I had determined this as *vittatus* Theob.; Dr. Dyar states that it is *sansoni*, and in Ins. Ins. Mens., 1917, p. 115, shows that *sansoni* and *vittatus* are the same. The name *vittatus* was published first, but it had earlier been used by Bigot for an insect which (as I learn from Dr. Dyar) Mr. F. W. Edwards now treats as a valid species of *Aedes*. *A. sansoni* is common in the Transition and Canadian Zones of Colorado: Boulder; S. Cottonwood Cañon near Buena Vista; two miles south of Leadville Junction; Crystal River near Red Stone (here also a small variety which looks distinct); three miles southwest of Salida; Upper Twin Lake. Prof. J. Henderson took it at 9,200 ft., southwest of Rabbit Ears, North Park, Colo., July 14, 1911, along with an *Aedes* with black tarsi and very long proboscis, not at present determined. A female which I collected at Estes Park Village, June 24, is said by Dr. Dyar to be near to or identical with *sansoni*.

(15) *Aedes stimulans* Walker. Recorded from Florissant, 1907 (Cockerell & Rohwer, on an old determination of Dr. Dyar's, when *sansoni* was not distinguished. It was presumably *sansoni*. I have, however, a very close relative of *stimulans* in a female from two miles above Minturn (P. Andrews). It is remarkable for the large palpi, and is certainly not *sansoni*. Dr. Dyar says it is new to him, but it is not described, as we have neither male nor larva.

(16) *Aedes triseriatus* Say var. *hendersoni* n. var. ♀. Dorsum of thorax anteriorly with at least lateral thirds covered with silvery scales; abdomen strongly purple, with the lateral white marks cuneiform, pointed mesad. 2 ♀. Box Elder Creek, 19 miles west of Douglas, Wyo., August 25, 1917 (Schwabe and Hen-

derson), with *A. cinereus* and *A. vexans*. Comparing this with *A. triseriatus* from New Jersey and New York, I thought it distinct, but Dr. Dyar doubts whether it is worth naming as a race. Dr. Dyar observes, however, that in Montana also the *triseriatus* has the silvery lateral areas of mesonotum enlarged, while in Texas and Maryland they are narrow (typical *triseriatus*), and in Florida they are still more reduced. That is to say, the silvery areas are most developed in the arid west, and most reduced in the humid south.

(17) *Aedes vexans* Meigen. Very common at lower levels, as along the eastern foothills and adjacent plains. Boulder, Camp Baldwin, Denver, Boone, Grand Junction, Rifle Range near Golden, Grand River 13 miles above Glenwood Springs. It is a species of the Transition Zone with us, and is not found in the high mountains. In Wyoming, it was found at Basin, Box Elder Creek, Shell Creek and near Ten Sleep, being evidently as abundant as in Colorado.

We also have a series of specimens of *Aedes* with black tarsi, which may represent two or three additional species; but as we have only females, and these mostly in bad condition, nothing definite can be said about them.

I am indebted to Mr. F. Knab for assistance, but also and especially to Dr. H. G. Dyar, who has sent me many named specimens, and has examined all my puzzling forms. Had it not been for his kind assistance and advice, I could not have ventured to write this paper at the present time.[1]

Adjournment.

SECTION ON APICULTURE

[The following is all of the proceedings received by the editor]

IMPORTANT FACTORS IN THE SPREAD AND CONTROL OF AMERICAN FOULBROOD

By E. D BALL

When the apiary inspection work of Wisconsin was recently placed in the writer's charge, a hasty survey was made of the existing situation in the state with reference to the occurrence of foulbrood and the method employed in inspection.

The situation was found to be serious and the inspection methods used totally inadequate under the conditions existing. On extending the survey to other states somewhat similar conditions were found to exist and often similar methods of inspection were in vogue.

[1] Since the above was written, Prof. C. P. Gillette has very kindly loaned the Culicid collection of the Colorado Agricultural College. This will be reported on at a later date.

From Inspector France's last biennial report we find that he visited 34 places and found foulbrood in 21 of them. If a line is drawn across the map of Wisconsin through Appleton and Eau Claire, thus separating it into northern and southern sections, it will be noted from his report that foulbrood was found in every county in which inspections were made south of that line, excepting three, and only a single place was visited in each one of these three counties. What would have been found if further inspection had been carried on can best be suggested by a glance at the maps showing the areas inspected this season.

North of the line mentioned 6 counties were visited and no foulbrood was found. This does not mean that foulbrood does not exist north of the line, as we have a number of records showing its presence in that region, but it probably indicates that there is far less of it in the northern district than in the southern.

Inspector Kindig in Bulletin 55 reports similar conditions in Michigan and the same difference between the northern and southern parts of the state. Inspector Rea of Pennsylvania in his latest publication reports conditions in that state much better than the above but notes some localities with similar conditions.

As a result of the survey of conditions it was decided that the "area clean-up" method of inspection was the only one that promised to cope with the existing situation, and so the work of the present season was organized along that line. The funds being limited, only three areas were undertaken. Two of these were chosen because active coöperation and support were assured from local associations, and the other to protect the University Experimental Apiary from contagion.

Owing to war calls and bad weather, less work was done than was planned and only parts of each area were covered. As far as the work went, however, every place where bees were kept or where they had been kept at any previous time was inspected. The old hives, frames, etc., in the honey houses or lying around outside were carefully gone over—every living colony was opened and at least four frames from the center of the brood chamber examined, even where no disease was found. Where disease was found in an apiary every frame was examined unless disease was found sooner. This method requires much work and care but the results obtained when charted and compared with previous knowledge were so strikingly different that there was no comparison—or rather that there was a very definite comparison possible.

The following table shows 161 apiaries inspected in 1917 of which 79 or one half of them had foulbrood. This is to be compared with 33

TABLE I—RESULTS OF THE SEASON'S WORK IN THE CLEANUP AREAS

Area No.	Apiaries Examined					Colonies Inspected	
	Total	American	European	Total Diseased	Free	Total	Diseased
1	67	21	24	41	26	2,327	357
2	76	28	—	28	48	1,811	317
3	18	10	—	10	8	385	78
Total	161	59	24	79	82	4,523	752

diseased apiaries found in the whole state in the previous two years of inspection service and only 7 of these in the three counties of which the three cleanup areas covered about one fourth. One fourth of 7 would be an average of 2 for the entire cleanup area but that would not be a fair basis as each cleanup was started from one of the previous cases, so this number should be doubled. But 4 diseased apiaries known where there proved to be 79 shows how really inefficient the old method was and how hopeless the expectation of ever cleaning up any bad area, such as these proved to be, by that method.

It would be foolish to say or to expect that these areas are "cleaned up"—they are not—but the actual condition is now known. Every owner knows his problem and has the knowledge necessary to success; many are already clean, others are on the watch and the reinspection will be comparatively easy in most cases. All this is, however, preliminary to the real object of the present paper.

In the inspection work one is frequently met by the statement that it is of no value to clean up foulbrood in the apiaries as long as the bee-trees cannot be inspected, as the disease will be redistributed over the area from this source. As bee-trees abound in a very large part of the honey-producing section of the state this seemed to be a problem worthy of careful consideration and investigation.

The writer was fortunate enough to be in the field while all the work was carried on in one part of area number 2, and tried to ascertain the source of each case of American foulbrood found in this district. The results were so striking and so at variance with the common belief as to the general means of spread of this disease that they have been plotted in Figure 1.

We see from the chart that the primary infection occurred along the Wisconsin River. This infection is apparently of long standing as most of the apiaries in the immediate neighborhood have been entirely destroyed for some years past. Mr. S.'s case is typical. He purchased bees from Mr. A. many years ago. From 112 swarms at one time his apiary dwindled down until not a single swarm was left alive. Mr. S. lives beside the only bridge across the river for many miles

and a sign on this bridge offering for sale the hives, frames and comb distributed this material over a wide area on both sides of the river. Not all of this area has been worked over but every infection with the exception of one (the origin of which is not known) in the region tribu-

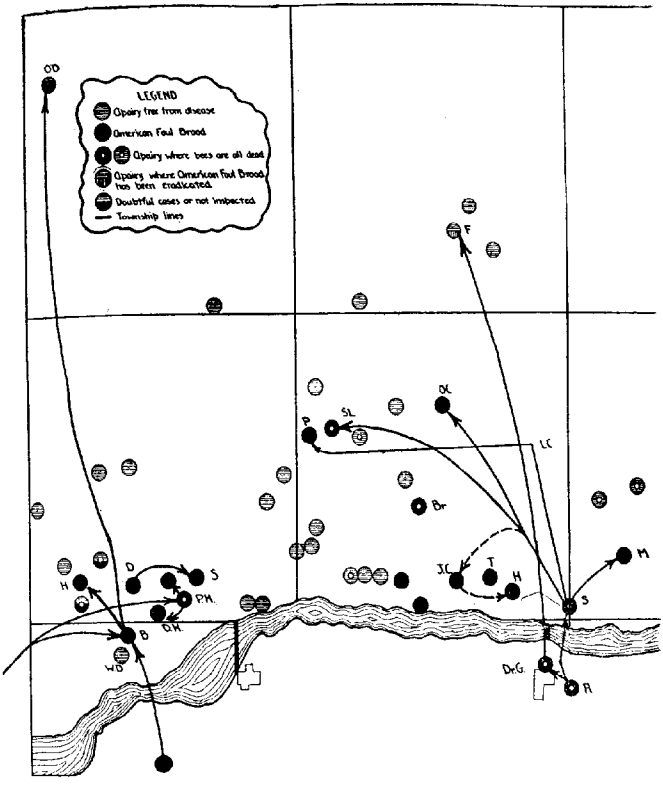


Fig. 9. A part of Area No. 2 showing the method of distribution of American foulbrood in this region.

tary to this bridge can be traced directly or indirectly back to this spot and to this method of distribution.

Two apiaries within a mile of each other are particularly illuminating in this respect. Mr. Sl. purchased a few empty hives from Mr. S. a number of years ago and placed them in a then prosperous apiary. Three years ago the last swarm of the apiary died and the entire out-

fit is now stored in a honey house. Mr. P., within a mile of this apiary on the same ridge, with bees covering the same pasturage, developed a prosperous apiary along side of this, apparently without infection until two years ago when the two remaining swarms of an apiary at some distance (L.C.) were purchased. This apiary had previously bought material from the original source at the bridge. When examined this year these two swarms were badly diseased and everything else in the apiary appeared to be recently infected. Mr. F., owner of a prosperous apiary in another section, bought two swarms from across the river and later discovered that they had foulbrood. He then destroyed them. Still later he found five or six more cases in his yards and destroyed these. His apiaries are now entirely free from disease as is the community.

Just below the next bridge is another badly infected area. Here the origin is somewhat obscure as there may have been two sources. Mr. B. and Mr. P.H. bought bees from another section further down the river several years ago. Mr. B. later bought a single hive from across the river. Soon after the first purchase their bees began to dwindle until Mr. P.H. lost every colony in the apiary where these bees were placed, while Mr. B. had only two left in his.

Five other apiaries in this section were found infected. Mr. B. sold to Mr. O.D., 12 miles distant, who has not been inspected as yet.

Of these five infections three are traceable directly to the two primary ones. Mr. G.'s case is instructive—he bought a few hives from his relative, Mr. D., and they were found badly infected as were Mr. D.'s, while the remainder of Mr. G.'s apiary was only just beginning to show the disease. Yet Mr. G.'s bees had been within a mile of Mr. P.H.'s during the time they died out while Mr. W.D.'s bees were even closer to Mr. B. and remained free from disease.

Out of 20 cases of American foulbrood in this area 15 are apparently definitely known to have been transmitted by the movement of hives and comb, while of the other 5 little information is available. In a number of cases the owners are related and would give little information in regard to possible sources, trying to magnify the importance of the bee-trees and minimize other possible sources. This investigation will be extended to the limits of this area and continued in other areas where the disease exists as they are surveyed, but if the findings of this area are borne out in other situations it will indicate that the most important method of preventing the spread of this disease is a strict quarantine of all infected material and the wide and persistent publicity of the fact that second-hand supplies should never be purchased except from recently inspected premises. Along with this should of course go the cleaning up and eradication of the disease in these areas,

but that work can go on with much more hope and encouragement if the "bogy" of the diseased bee-tree and the wide transmission of this disease by infected honey can be first eliminated from the minds of the people in country districts and in their place substituted a hope and expectation of freedom from the disease as a result of the "area clean-up" method of treatment.

[Papers read by Title]

AN EMERGENCE RESPONSE OF TRICHOGRAMMA MINUTUM RILEY TO LIGHT[1]

By GEORGE N. WOLCOTT

While temporarily employed by the U. S. Bureau of Entomology from June to August, 1917, to work on sugar-cane insects in the Rio Grande Valley, Texas, the writer collected large numbers of egg clusters of the sugar-cane moth stalk borer, *Diatræa saccharalis* Fabr. After trying various localities in the valley where sugar-cane was grown, Harlingen, Texas, was selected for continuous work, as in two fields there about a mile north of the railroad station, *Diatræa* was very abundant. In all, 1,506 clusters were collected from these two fields, and of these 944, or 62.6 per cent, were parasitized by the hymenopteron, *Trichogramma minutum*.

The individual *Diatræa* egg is oval and flattened, lenticular in cross-section, and these plate-like eggs are deposited in single, double or triple (or irregularly four, five, and sometimes even six) rows, overlapping like shingles or slates on a roof. The following table gives the number of eggs in the masses, and the frequency with which different numbers occurred:

Number	*Frequency*	*Number*	*Frequency*	*Number*	*Frequency*
3	2	18	66	33	19
4	1	19	76	34	14
5	1	20	50	35	16
6	7	21	56	36	11
7	19	22	55	37	10
8	20	23	53	38	11
9	35	24	44	39	5
10	38	25	40	40	5
11	47	26	30	41	11
12	48	27	36	42	4
13	50	28	27	43	6
14	49	29	17	44	2
15	64	30	21	45	6
16	63	31	11	46	5
17	66	32	27	47	7

[1] Published by permission of the Chief of the Bureau of Entomology.

Number	*Frequency*	*Number*	*Frequency*	*Number*	*Frequency*
48	3	53	2	60	1
49	2	54	1	67	1
50	1	55	1	68	2
51	2	56	1	70	1
52	3	59	2	71	1

The eggs are creamy white when first laid, becoming yellower in a few hours, orange in a couple of days, and when nearly ready to hatch the dark brown head of the young caterpillar can be seen through the transparent shell. The clusters parasitized by *Trichogramma* become black soon after parasitization, and after the emergence of the parasite the eggs are still black because of the black débris remaining; while of the unparasitized eggs only a whitish egg shell is left when the caterpillar hatches out. It is thus possible to tell definitely, except when freshly parasitized, which clusters and which eggs in the cluster are parasitized. Of 380 clusters on which data are available, 65.3 per cent were totally parasitized and 34.7 per cent only partly parasitized, 20 per cent of the eggs in these clusters being not parasitized.

The egg-masses are impartially deposited on either the upper or lower side of the cane leaves. They may be on the midrib or on any other part of the leaf, even to the edge, but usually they occur from the center to the tip, rather than closer to the stem of the plant. In collecting *Diatræa* egg clusters a portion of the leaf surrounding the egg-mass was broken off and placed in a tin box. All collections were made between the hours of 7 a. m. and 10 a. m. In the afternoon the bits of leaves bearing the egg-masses were removed from the tin boxes one by one and trimmed so as to go easily into a 7 mm. x 25 mm. vial. Corks were used to close the vials after they had been allowed to dry out for half an hour or more, and a wad of absorbent cotton was packed down in the bottom of the vial on the opposite side of the piece of leaf from that bearing the eggs. In this way the moisture exuded and transpired was largely eliminated and the piece of leaf was held securely in place. Unless the cotton was tightly packed in, however, the emerging caterpillars, and especially the adult *Trichogramma*, became inextricably entangled in the loose fibres. Both young *Diatræa* caterpillars and adult *Trichogramma* are positively phototropic to a very marked degree, and when the bottom of the vial was towards the window, they would push into even the most tightly wadded piece of cotton in their efforts to reach the source of light. When the vials have the corks towards the window, some of the *Trichogramma* manage to get between the cork and the edge of the vial, and are often crushed when the cork is removed, while the young *Diatræa* caterpillars will bore into the dry cork, often making a tunnel several times their own length. To obviate the difficulties connected with the phototropic

reactions of the emerging insects, the vials were kept in the dark and only exposed to light for a short time each day, when observations on emergence were made.

Upon removing the vials from the dark the great majority would show no *Trichogramma* adults emerged, but as one continued looking over them, *Trichogramma* would begin to appear in vials in which none had been visible when first examined. Some of the tiny insects would have their wings not yet expanded, and others would show only one red eye or the entire head looking out from the hole in the egg shell, but in five or ten minutes the vial would be full of the active little wasps. To determine just how definite was this emergence response of *Trichogramma* adults to light, a large number of observations were made at various times of day.

The method of procedure was to remove the vials from a large cardboard mailing tube, with a screw top tin cover, one by one. The emerged *Trichogramma* adults were counted as they left the vial when the cork was removed and the open end turned towards the light. These vials were placed in order in front of the window, while the vials containing egg clusters from which no adults had emerged were also placed in regular order in the same situation, but in a separate row. At the end of an hour the vials were again examined, *Trichogramma* adults counted as they left the vials, and the vials returned to

Material Collected August 1			Material Collected July 30			
Vial No.	Emerged between 6 p.m. Aug. 3 and 9 a.m. Aug. 4	Emerged between 9 a.m. and 10 a.m. Aug. 4	Vial No.	Emerged between 7 p.m. July 30 and 1.05 p.m. July 31	Emerged between 1.05 p.m. and 2.05 p.m. July 31	
	Dark	Light		Dark	Light	
1	3	14			1.10 p.m.	
2	4	11	1	10	0	10
3	2	12	2	6	0	16
4	4	5	3	12	0	3
5	1	23	4	5	0	12
6	4	11	5	9	0	19
7	7	11	6	0	5	20
8	3	25	7	0	5	12
9	33	0	8	8	5	7
10	0	22	9	0	0	8
11	0	8				
12	0	1		42	15	102+15
13	0	27				
14	0	31				
15	0	1				
16	0	27				
17	0	4				
18	0	17				
19	0	7				
20	0	4				
	61	258				

61 emerged in Dark
258 emerged in 1 hour Light
Ratio 4.23

42 emerged in Dark
15 emerged in 5 minutes Light
117 emerged in 1 hour Light
Ratio 2.78

the dark mailing tube. The ratio of the total number of adults which had emerged before exposure to light as compared with the total number which emerged after exposure to light, either from egg clusters from which no adults had previously emerged or from which some adults had already emerged, expresses what has been assumed to be the emergence response to light. A few examples of individual daily observations are given.

In the following table, all the observations, summarized, are given.

RATIOS OF EMERGENCE RESPONSE OF TRICHOGRAMMA TO LIGHT

Days after Collection	7 a. m.	9 a. m.	10 a. m.	11 a. m.	12 m.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	6 p. m.	Average
1	25.33	66 / 2.12	2.69	1.08	1.27	2 / 2.78	2.17	....	.47	.2	3.7
2	....	2.28	3.36	.67	....	1.51 / .65 / .93	.73	.71	1.22	....	1.34
3	5.11	4.23	1.71	....	.25	1.26	....	....	.42	.12	1.87
4	....	....	....	.95	.36	.4	.25	.81	....	....	.55
5	....	1.55	....	....	....	....	.21	....	....	....	.88
6	....	....	....	....	....	....	.35	....	....	.5	.42
Average	15.22	2.17	2.59	.9	.63	1.36	.74	.76	.7	.27	....

The number of hours between the observations on succeeding days bore no constant relation to the emergence response, and is not indicated. It is obvious that the emergence response is not as strong several days after collection. This may be due to unnatural conditions of moisture, curling of the bit of cane leaf, or fungus growing on it, but it may also be a result of the lessened chance of an organism responding to light when it has experienced only one twelfth (±) as much as it normally would receive. There was no way to differentiate between the egg clusters from which *Trichogramma* would emerge in a few hours and those in which several days were necessary for development, and both consequently received the same treatment. Thus the adults emerging in four or five days received ordinary room light for only four or five hours plus the light before collection, while those emerging the next day after collection had been exposed to bright sunlight twelve or more hours a day, except for a short period just prior to emergence.

It is also to be noted that the emergence response of *Trichogramma* is not as strong in the late morning, or afternoon, as earlier in the day. This is to be expected. In the field, *Trichogramma* adults just emerged from the eggs have been observed at the following times: 7.15 a. m. (July 24), 8.15 a. m. (July 27), 8.05 a. m. (August 1), 7.45 a. m. and 8.10 a. m. (August 7), 7.15 a. m. (August 9), 8.45 a. m. (August 13), 8.15 a. m. (August 14). The average of these times is 8.06 a. m. Adults have not been seen at other times, although obser-

vations have been made at all times of day. The normal time of emergence is thus approximately two hours after sunrise, but if sunrise —as far as the eggs are concerned—is artificially delayed by keeping them in the dark, emergence will also be delayed. To just how great an extent, and how lack of light fails to prevent emergence late in the day, the summarized data in the foregoing table has shown. But this is hardly a fair comparison, and in the following table the ratios represent the adults emerging in the first hour of exposure to light as compared with the adults emerging in the dark, per hour of previous daylight in the same day, or rather after 7 a. m.—which is apparently as early as daylight is effective.

Days after Collection	7 a.m.	9 a.m.	10 a.m.	11 a.m.	12 m.	1 p.m.	2 p.m.	3 p.m.	4 p.m.	6 p.m.	Average
1	25.33	4.25 1.33	8.08	4.31	6.36	12. 16.71	15.22	....	4.24	2.26	9.09
2	....	4.56	10.08	2.4	....	9.– 4.– 5.44	5.1–	5.62	10.97	....	6.35
3	5.11	8.46	5.–	....	1.42	....	....	....	3.77	....	4.75
4	....	....	....	3.78	1.8–	7.65	1.76	6.54	....	....	4.3
5	....	3.1–	....	....	....	2.42	1.48	....	....	....	2.33
6	....	....	....	....	....	....	2.	....	....	5.5	3.75
Average	15.22	4.34	7.71	3.5–	3.2–	8.17	5.11	6.08	6.32	3.88	....

The average of 35 experiments indicates that six (6.19) times as many adults of *Trichogramma minutum* emerge in the first hour after being exposed to daylight, as emerge in the dark per hour of previous daylight in the same day.

NOTES ON SOME SOUTHWESTERN BUPRESTIDÆ[1]

By H. E. BURKE, *Specialist* in Forest Entomology, Bureau of Entomology, U. S. Department of Agriculture

The following paper gives the host plants and some biological notes on eighteen species of flathead borers (*Buprestid* larvæ) mostly from Sabino Canyon, Santa Catalina Mts., Arizona. Larvæ and sections of infested wood were collected in the field and shipped to the Forest Insect Laboratory, Los Gatos, Calif., where the adults were reared. Practically all of the collections were made by Specialist W. D. Edmonston and Entomological Rangers George Hofer and Morris Chrisman.

The names given are taken from Henshaw's "List of the Coleoptera of America, North of Mexico" and are those commonly used. The writer is responsible for the identification of the larvæ and Mr. W. S.

[1] Published by permisson of the Secretary of Agriculture.

Fisher of the Branch of Forest Insect Investigations for practically all of the adults.

Several of the species are of considerable economic importance because their winding larval mines riddle the wood of the mesquite and other southwestern shrubs and trees. Posts and piles of mesquite firewood are sometimes severely damaged by the work of *Chrysobothris octocola* and closely related species.

A few of the species such as *Melanophila pini-edulis* will kill trees or parts of trees but the majority of them are secondary and attack the tree only after it starts to die or is already dead.

Psiloptera sp. possibly webbi Lec.—Specimens from Arizona; mines wood of old dead trees; palo verde (*Cercidium torreyanum*); one larva found in the heartwood of an old dead tree in Sabino Canyon.

Melanophila pini-edulis Burke.—Colorado, Utah, Arizona; mines bark and outer wood of the limbs and trunk of dying, dead and living trees of the pinion (*Pinus edulis*); in the laboratory emerges during June, July and August; assists Scolytids and Cerambycids to kill trees.

Chrysobothris octocola Lec.—Arizona, Texas; mines bark and wood of injured, dying and dead shrubs and trees; mesquite (*Prosopis juliflora*) and palo verde (*Cercidium torreyanum*); in the laboratory emerges from the wood in August and September; the larval mines riddle the wood and often cause severe injury to mesquite posts and firewood.

Chrysobothris edwardsii Horn.—Arizona; mines bark and wood of dying and dead stems; ocotillo (*Fouquieria splendens*); in the laboratory emerges in August and September.

Chrysobothris debilis Lec.—Arizona; mines bark and wood of dying and dead limbs and trunks of shrubs and trees; live black oak (*Quercus emoryi*), palo blanco hackberry (*Celtis reticulata*), cats claw (*Acacia greggii*), mesquite (*Prosopis juliflora*) and palo verde (*Cercidium torreyanum*); in the laboratory emerges from May to October.

Chrysobothris axillaris Horn.—Arizona; mines bark and sapwood of dying and dead limbs of live black oak (*Quercus emoryi*); in the laboratory emerges in July.

Chrysobothris ignicollis Horn.—Colorado, Arizona; mines bark and sapwood of dying and dead limbs of living trees and also dying and dead trees; Rocky Mountain juniper (*Juniperus scopulorum*) and probably alligator juniper (*Juniperus pachyphlœa*); flies in July.

Chrysobothris ludificata Horn.—Arizona; mines bark and sapwood of dying and dead limbs, logs and stumps; western yellow pine (*Pinus ponderosa*); according to Mr. A. J. Jaenicke of the Forest Service this is the common species on yellow pine slash in northern Arizona; flies in June.

Chrysobothris trinervia Kirby.—South Dakota, Colorado; mines bark and sapwood of dying and dead limbs and trees; limber pine (*Pinus flexilis*) and western yellow pine (*Pinus ponderosa*); according to Mr. B. T. Harvey this species kills young yellow pine saplings in the Black Hills of South Dakota by girdling them close to the ground; in the laboratory emerges in June, in the field flies in August.

Chrysobothris breviloba Fall.—Colorado; mines bark and sapwood of dying and dead trees; western yellow pine (*Pinus ponderosa*); according to Mr. B. T. Harvey this species lays its eggs between the scales of the bark; flies in July and August.

Chrysobothris exesa Lec.—Arizona; mines bark, sapwood and heartwood of dying and dead trees; mesquite (*Prosopis juliflora*); young beetles found in the heartwood of dead trees in February and March; in the laboratory emerges in June.

Chrysobothris texana Lec.—Colorado; mines bark and wood of dying and dead trees; Mountain juniper (*Juniperus scopulorum*).

Chrysobothris gemmata Lec.—Arizona; mines bark, sapwood and heartwood of dying and dead limbs and trunks; mesquite (*Prosopis juliflora*); present observations indicate that this species may kill branches and entire trees; the work causes severe injury to the wood.

Chrysobothris merkelii Horn.—Arizona; mines bark, sapwood and heartwood of dying and dead stumps, limbs and trees; cats claw (*Acacia greggii*) and mesquite (*Prosopis juliflora*); may kill trees; young beetles taken from the wood in February.

Actenodes calcarata Chev.—Arizona; mines sapwood and heartwood of dying and dead trees; palo verde (*Cercidium torreyanum*) and probably bacchata (*Zizyphus obtusifolia*).

Acmœodera conoidea Fall.—Arizona; mines dead flower stalks of the sotol (*Dasylirion wheeleri*); in the laboratory emerges in August and September.

Acmœodera larreæ Fall.—Arizona; mines heartwood of dying and dead stems of the creosote bush (*Covillea tridentata*); adults taken from the wood in January.

Tyndaris olneyæ Skinner.—Arizona; mines sapwood and heart wood of dead limbs; cats claw (*Acacia greggii*), mesquite (*Prosopis juliflora*) and palo verde (*Cercidium torreyanum*).

NOTES ON FALSE WIREWORMS WITH ESPECIAL REFERENCE TO ELEODES TRICOSTATA SAY[1]

By JAMES W. MCCOLLOCH, *Assistant Entomologist*, Kansas State Agricultural Experiment Station

With the establishment, in 1915, by the Department of Entomology, of project No. 100, dealing with a study of those insects injuring the roots and germinating seeds of staple crops, the writer undertook a study of the available species of the tenebrionid genus *Eleodes*.

There are two primary reasons why this group of insects was chosen as a part of this project. First, practically nothing is known concerning the life-histories of the various members of this genus. Swenk (1909) partially worked out the life-history of *E. opaca* Say, and Hyslop (1912) gives a short synopsis of the life-history of *E. letcheri vandykei* Blaisd. According to Gebien (1911, pp. 242–252), the genus is a large one, containing 123 species. Eleven of these species have been recorded from Kansas. Second, the beetles of the genus *Eleodes* are native insects confined principally to the semi-arid regions west of the Mississippi River. In fact, only three species, *tricostata*, *opaca*, and *suturalis* (Wickham, 1899) have been recorded east of Kansas. In Kansas, they are typical of the native prairies and farther west they are found in the sage brush areas. The gradual breaking out of these prairies is depriving these insects of their native food and is forcing them to feed on the more succulent cultivated crops. Just how successful the different species are in becoming adapted to the new conditions is an interesting problem. *E. opaca* has already become a serious pest of wheat in Kansas and Nebraska. *E. letcheri vandykei* has appeared in cultivated fields in the Pacific Northwest, and, in 1913, *E. extricata* var. *convexicollis* Blaisd. was found attacking grains in Montana.

The life-histories of several species have now been studied at the Kansas Experiment Station and that of *E. tricostata* will form the basis of this paper. Reference will be made to other members of the genus, especially when they touch on the species under consideration.

ECONOMIC IMPORTANCE OF THE GENUS

It is only within recent years that the false wireworms have been recognized as pests of growing crops. Blaisdell (1909, p. 29) states

[1] Contribution from the Entomological Laboratory, Kansas State Agricultural College, No. 32. This paper embodies some of the results obtained in the prosecution of project No. 100 of the Kansas Experiment Station.

that as far as he has been able to determine, species of this genus are neither injurious nor beneficial, unless the larvæ are in some way troublesome. Riley (1884, p. 90) records the adult of *E. quadricollis* Esch. injuring the foliage of grapes in California. This species is said to have destroyed 35 acres of grape vines. Bruner (1892, p. 12) found *E. tricostata* injuring cabbages and other garden crops at Lincoln, Nebraska. Swenk (1909, pp. 332–333) gives an account of the serious damage done to planted grain, especially wheat, by *E. opaca* in western Nebraska. Hyslop (1912, p. 75) states that the results of three years' work demonstrate quite conclusively that the false wireworms are among the most destructive insects to recently planted wheat and corn in the Pacific Northwest. *E. pimeloides* Mann. and *E. letcheri vandykei* are discussed especially in this regard. Webster (1912, p. 32) reports *E. sulcipennis* Mann. feeding on the larvæ of alfalfa weevil and *E. suturalis* Say eating chinch bugs. Essig (1915, pp. 290–291) records the adult of *E. omissa borealis* Blaisd. as feeding on the leaves of apricot, orange, plum, and watermelon. Cooley (1916, p. 154) has found *E. extricata* var. *convexicollis* Blaisd. very abundant in Montana and in several instances seriously injuring newly sprouted grain.

The above references comprise most of the known reports of the injuries by this genus. That more is not known concerning them is probably due to a number of factors. The larvæ closely resemble the true wireworms and considerable confusion has resulted. Much injury attributed to wireworms, especially in the semi-arid regions, is probably due to the false wireworms. The larvæ are subterranean in their habits and move with great rapidity through the soil, hence it is often impossible to find them at work. The adults are largely nocturnal in their habits, and although they may be extremely numerous in a locality, they are seldom found without a diligent search.

Economic Importance of Eleodes tricostata

The data on the economic importance of *E. tricostata* are very meager. Wickham (1890, p. 86) states that it feeds on the roots of grasses, and Bruner (1892, p. 12) found it seriously injuring cabbages and other garden crops at Lincoln, Nebraska, and states that it was doing more damage than cutworms. He also says that it is a general feeder upon the prairies and on weeds in the field. Hunter, Pratt, and Mitchell (1912, p. 51) list *E. tricostata* among the insects incidentally associated with the cactus plant.

In Kansas, *tricostata* appears to be confined almost entirely to the native pastures where the larvæ feed on the roots of the various grasses occurring there. Practically all the adults and larvæ collected in the

field have been taken in such situations. A few larvæ and adults have been found in wheat and corn fields, but the data thus far collected indicate that this species is a pest of our native prairie grasses. In the laboratory, however, the adults and larvæ feed readily on germinating wheat and corn and there seems to be no reason why this should not occur in nature. The adults also feed freely on young wheat plants growing in the cages.

Distribution

E. tricostata is one of the more widely distributed species of this genus. Blaisdell (1909, pp. 38 and 107–108) records it from Texas, New Mexico, Oklahoma, Utah, Kansas, Nebraska, Iowa, Idaho, Montana, Colorado, Wyoming, South Dakota, and British America. Say (1823, p. 262) gives the type locality as Missouri and Arkansas. Wickham (1899, p. 60) says it extends as far east as Independence, Iowa, where he found it in September on a broad, dry sand-flat along the Wapsipinicon bottom. Stoner (1913, p. 81) records taking *E. tricostata* at Fergus Falls, Minnesota, in 1911. This is the first known record of a species of *Eleodes* being taken in that state. In Kansas, this species is distributed over most of the state. Popenoe (1877, p. 36) says that it is common throughout the state and the collection of the Department of Entomology contains specimens from all regions of Kansas except the southeastern part.

Methods of Rearing

In carrying out the life-history study, the writer found the following methods successful in rearing each of the different stages. Eggs were placed in small vials closed with cotton plugs and kept in the field insectary under outdoor conditions. The larvæ on hatching were placed in one-ounce tin boxes containing slightly moistened soil and a small amount of bran for food. As the larvæ became larger, they were supplied with germinating wheat instead of bran for food. During the summer, it was necessary to change the soil in these boxes about every ten days, but in winter when the larvæ were rather inactive, it was changed about every three weeks. The pupæ were kept in the same boxes in which the transformation took place. The adult beetles were confined in pint fruit jars, containing about an inch of dry soil and a little bran.

With the exception of the eggs, all stages were kept in the cement cave previously described by the writer (1917) where the temperature more nearly approximated subterranean conditions. During the summer months, the temperature of the cave varied from 70° to 80° F. With the approach of cold weather, the temperature gradually fell

until early in March when it was about 40° F., after which time it began to rise slowly. The results obtained in the life-history work in the cave coincided closely with the field observations made throughout the year.

Description and Life Economy

The Egg.—The eggs (Pl. 5, A) of *E. tricostata* are bluntly oval longitudinally, and circular in diameter. They vary in length from 2.2 mm. to 2.5 mm. and are about 1.2 mm. in diameter. The eggs of this species are much larger than any so far described for the genus. Blaisdell (1909, p. 496) states that the eggs of all species of *Eleodes* which he has examined are about 1 mm. in length. The freshly laid eggs are white in color with no surface markings. As development takes place the color changes to a light creamy yellow.

When deposited, the eggs are coated with a sticky solution which causes a thin layer of dirt to adhere to them, making them hard to find in the field. They are laid singly, although several may be placed in the same cavity. In the rearing cages, the females seemed to prefer dry dirt for oviposition as practically all of the eggs were found in the driest dirt. In oviposition, the female excavates a cavity one-fourth inch to three inches in depth and deposits from one to four eggs, after which she fills the hole with dirt.

In hatching, the young larva splits the egg shell at the end and down the side about one-third the way. The larva usually emerges head first but it is not unusual for the reverse to occur. The egg shell appears to be broken by the larva arching the body and this may cause the shell to break at either the anterior or posterior end. When the larva emerges head first, the process requires a very short time, but when it emerges with the posterior end first, several hours may be consumed in emerging, and, in some cases, the larva may be unable to free the head from the shell.

The length of egg stage was determined for 300 eggs in 1915 and 4,800 eggs in 1916. The following table gives the essential data:

Incubation Period

Date	No. Eggs Hatching	Min. Days	Max. Days	Average Days
1915	300	10	30	14.5
1916	4800	6	46	14.0

The length of the egg stage varies with the season of the year. Eggs laid during July and the first half of August hatched in from 6 to 11 days. After the middle of August the length of the egg stage increased

rapidly until November when it was about 46 days. In 1916, the first eggs were deposited on July 10 and the first ones hatched on July 16. The last eggs were laid October 12 and the last egg hatched November 20. This gives a period of 133 days that eggs were to be found.

THE LARVA.—Very little has been written concerning the larvæ of *Eleodes*. Gissler (1878, p. 19) gives a meager description of the larvæ of *E. gigantea* Mann. and *E. dentipes* Esch. Blaisdell (1909, pp. 497–499) enlarged on the description of *dentipes* and gives a working basis for the description of the various larvæ of the genus. Hyslop (1912, pp. 78–81) describes the larvæ of *E. letcheri vandykei* and *E. pimeloides*. In many ways the false wireworms resemble the true wireworms but may be readily distinguished from them by the fact that the antennæ of the *Eleodes* larva are clavate and longer. The false wireworms also show a much greater activity than do the true wireworms.

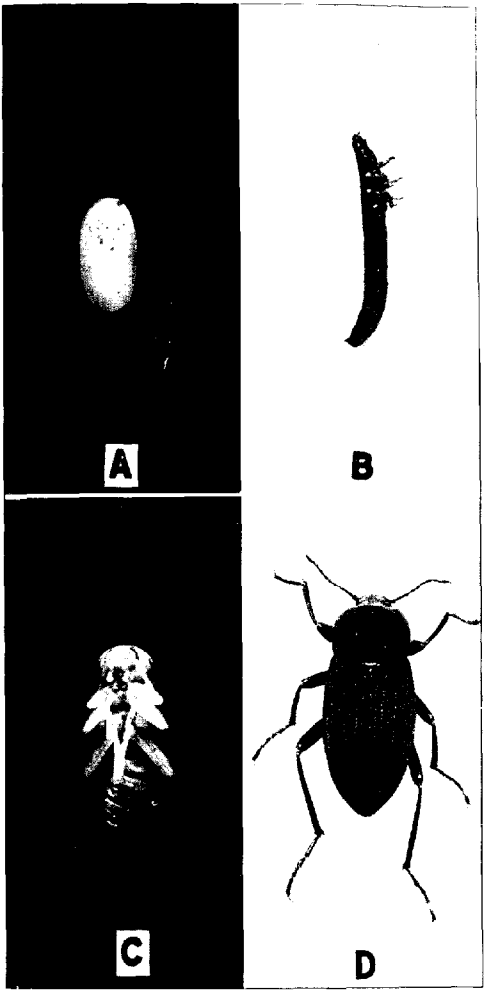
On hatching, the larva (Pl. 5, B) of *E. tricostata* is 3.75–4 mm. in length and creamy white in color. After the first moult, the larva changes to black in color and this color persists, except immediately after moulting, during the rest of this stage. In this respect, it differs from any of the described *Eleodes* larvæ. When full grown, the larva is about 35 mm. in length.

The larvæ are subterranean in their habits, being found during the summer and fall from one to six inches or more below the surface of the ground. It is not uncommon to find them under stones on grass-land but so far the writer has never observed them on the surface of the ground. They burrow from place to place, feeding on the roots and seeds of plants and probably, to some extent, on decaying organic matter. In the vicinity of Manhattan, the larvæ appear to be confined to the native grass-land and practically all larvæ found have been taken in such situations. In confinement, however, they feed readily on germinating wheat and corn, on bran, roots of grasses, and, to some extent, on manure. In addition to this, they often feed on their cast-off skins and on larvæ that have died or are in a weakened condition.

The length of the larval stage was determined for 111 larvæ in 1915 and 1916, these data being summarized in the following table:

LENGTH OF LARVAL STAGE

Year	No. of Larvæ	Min. Days	Max. Days	Average Days
1915–1916	51	252	291	267
1916–1917	60	68	332	292



Elaphidion tricostatum Say. A, egg; B, larva; C, pupa; D, adult.

Most of the worms reached the next to the last moult during the summer and fall and passed the winter in this condition. From the first of November to the first of March they fed but little and were very inactive. Commencing the first week in March, they began feeding again and moulted during April or May. The first larva pupated May 27 and the last larva on June 30. Field data bear out this study. Practically full-grown larvæ were found in the grass-land during early April. These moulted and pupated about the same time as those reared. It is interesting to note that five larvæ, hatching from eggs laid early in July, 1916, pupated during October and November. The average length of the larval stage in this case was 77 days. Before pupation, the larvæ enter a semi-pupal or quiescent stage, which lasts from five to ten days. During this time they do not feed and are very inactive.

In rearing the larvæ, it was found that they made their best growth when placed in boxes containing soil with bran and wheat for food. When fed on decaying matter and roots they made a much slower growth and in nearly every case failed to reach maturity. About 200 larvæ were reared in boxes containing nothing but dry bran. Most of these lived from three to six months but they made very little growth and moulted only once.

THE PUPA.—The pupæ (Pl. 5, C) are white in color after transformation and are 15–19 mm. in length. As development proceeds, the body color changes to creamy yellow and the mandibles, legs, and antennæ become dark in color. At the end of 14 to 16 days the mandibles and claws show a deep reddish-brown color.

Pupation took place in the spring of 1916 during the last week in May and the entire month of June. The first larva pupated on May 27 and the last one pupated June 30. Maximum pupation occurred on June 4. The pertinent data on the length of the pupal stage are shown in the following table:

LENGTH OF PUPAL STATE

Year	No. of Pupæ	Min. Days	Max. Days	Average Days
1916	49	11	22	19.4
1917	32	13	45	17.0

In one case, a larva pupated October 14, 1916, and the adult issued November 28, giving a pupal stage of 45 days. Another individual pupated October 23, 1916, and passed the winter in this stage, dying in April, 1916.

THE ADULT.—The adult beetles (Pl. 5, D) are oblong oval, black,

and clothed with short setiform hairs, each arising from a puncture. Each elytra bears three distinct costæ which are more or less coarsely muricate. The female is robustly oblong, the elytra usually being widest at the middle. A tuft of ordinary piceous spinules occurs on the tip of the first joint of the anterior tarsus; the second joint is unmodified. The male differs from the female in that the body is more oval in shape, the elytra usually being widest at the base. There is a slight modification of the first two segments of the anterior tarsus. The males are 13–20 mm. in length and about 6.5–10.5 mm. in width, while the females are somewhat larger in size, being 14–22 mm. in length and 7–11 mm. in width.

In the life-history studies, adults emerged from the pupal stage June 16 and continued to emerge until July 10, the maximum emergence occurring about June 24. Field studies coincide very closely with these results. During the early part of June, it was almost impossible to find adults in the field. Beginning about June 20, however, adults became numerous and most of them were of a bright color and the body soft, showing that emergence had just taken place.

E. tricostata may pass the winter as an adult as well as in the larval stage. During March and April of 1916, several adults were found hibernating in spherical cells under rocks. The mortality, however, is very high, varying from 50 to 95 per cent. The writer has never been able to obtain eggs from these overwintering beetles.

While most of the adults emerged before June 24, mating was not observed until July 7, when it became general in many of the cages and continued until the middle of September. The first eggs were deposited July 10, three days after copulation was noted. Egg laying continued until October 12, at which time the beetles became inactive and appeared to have entered hibernation.

Thirty-one mated females, confined in cages containing about one inch of soil, deposited a total of 5,464 eggs or an average of 176 eggs per female, with extremes of 103 and 262. The largest number of eggs deposited by a single female during a period of 24 hours was 51. The average period of oviposition for this experiment was 48.8 days, the longest being 75 days and the shortest 24 days. An average of 3.7 eggs were laid on each day. The average number of days on which eggs were laid by each female was 23.6, with extremes of 11 and 37 days. The average number of eggs laid was 8.

The proportion of sexes was determined for 1,257 beetles collected in the field during the summers of 1916 and 1917 and the males seemed to predominate, since only 551 of the beetles collected were females while 706 were males. Approximately the same proportion of sexes has prevailed in the rearing work.

The habits of the beetles have been studied to a limited extent in the field. All of the *Eleodes* are more or less nocturnal or crepuscular and *tricostata* is no exception. They may be found abroad early in the morning and towards evening or on cloudy days. During the daytime, however, they are generally found under rocks, boards, logs and manure where they are rather inactive. Once the cover is removed, however, they run with great rapidity. Feeding, mating, and egg laying take place generally at night, both in the field and in the rearing cages.

The adults have been found feeding in the field on *Solidago*, *Euphorbia marginata*, prairie clover, and evening primrose. In the laboratory, they fed on bran and soaked wheat in preference to any other food supplied. They also fed readily on growing wheat plants, especially when the plants were only a few inches high. Some of the beetles fed sparingly on roots and leaves of grasses and on decaying organic matter. They are also cannibalistic to some extent, feeding on dead beetles or those in a weakened condition.

The beetles of *E. tricostata* live for a long period. One female collected early in July, 1915, lived until May, 1916, while many beetles maturing in June, 1916, lived until June and July, 1917. The longest period thus far recorded is for a female that lived 391 days. There seems to be a tendency for the females to live longer than the males. Blaisdell (1909, p. 29) records keeping adults of *E. dentipes* alive for over four years.

Length of Life-Cycle

The length of the life-cycle normally occupies about one year. Taking the average length of the various stages, it required 328 days from the time the eggs were laid until the adults emerged. In the same way, using the minimum length of each stage, the life-cycle was 85 days, and taking the maximum length of each stage, the life-cycle was 423 days.

Predaceous Enemies

The members of the genus *Eleodes* are not preyed upon by a large number of predaceous enemies. This is probably due to the fact that the adults of most of the species secrete an oily liquid having a strong offensive odor. This is thought to be a protective secretion as it is excreted only when the beetles are disturbed. Gissler (1879) describes the glands which produce this fluid and states that they are found in both sexes. Williston (1884, p. 169) says that *E. tricostata* seems to be devoid of these secretions.

Blaisdell (1909, p. 29) says that skunks will feed on *Eleodes* and that chickens devour them readily as do the ground owls. The butcher

birds impale them on thorns. Hyslop (1912, p. 84) states that the records of the Bureau of Biological Survey list thirteen species of birds as feeding on the adults of *Eleodes*. Barrows and Schwarz (1895, p. 64) found *Eleodes* in the stomach of crows in Kansas and Nebraska, and they state that these beetles fulfil most of the requirements of insect food preferred by the crows. Judd (1898, p. 25) records the loggerhead strike as feeding on *E. tricostata* and Beal (1900, p. 70, and 1911, p. 40) has found specimens of this species in the stomachs of the crow blackbird and the red-headed woodpecker.

Parasites

Very few parasites have been found attacking any of the *Eleodes*. Bruner (1892, p. 12) records eggs of a tachinid on the elytra of *tricostata* and *opaca*. Riley (1892, pp. 211 and 219) records a braconid parasite, *Perilitus* sp., from *E. suturalis*. Hyslop (1912, p. 35) found a nematode worm infesting the abdomen of a beetle. He states that the worm nearly filled the abdomen. Ellis (1913, pp. 282–283) describes a gregarine (*Stylocephalus giganteus*) obtained from *E. hispilabris* Say and *Eleodes* sp. During the past summer, the writer found this same gregarine in the alimentary tract of *tricostata* and *opaca*. Aldrich (1915, p. 245) reports a *Sarcophaga* larvipositing on *E. tricostata*, *E. hispilabris*, and *E. obsoleta* Say.

On August 7, 1916, a number of hymenopterous larvæ were found in one of the *tricostata* cages. On examining the beetles, they were found to be coming out of the anal slit of a male. Shortly after emerging they spun silken cocoons around the edge of the cage and pupated. The adult parasites emerged August 16 and were found to be *Perilitus eleodis* Viereck.[1] This same parasite was reared from *E. opaca* on August 23.

A red mite, *Trombidium* sp., was found on a number of beetles collected July 3, 1917. These mites were attached to the legs and to the various sutures on the ventral side of the body. The beetles were placed in a cage but the mites soon disappeared and none of the beetles died.

A little life-history work was carried on with *Perilitus eleodis* and it might be of interest to note some of the results obtained. The larvæ emerge through the anal slit of the beetle and seek a place to pupate. As they move from place to place they leave a trail of silken thread and, where large numbers of larvæ emerged in a cage, the soil was often webbed together. Shortly after emerging the larvæ construct silken

[1] Determined by Mr. A. B. Gahan, of the Bureau of Entomology, U. S. Department of Agriculture.

cocoons in which they pupate. In spinning these cocoons the soil is webbed together, making it difficult to find them. In the rearing work, the larvæ would not construct cocoons unless there was soil present. The length of the pupal stage was determined for several hundred parasites and was found to range from 8 to 15 days, with an average of 9 days.

On emerging, the adults are rather active but make little effort to fly. On placing the parasites in cages containing adult beetles, they were found remaining close to the ground and apparently trying to get under the beetles. Shortly after introducing parasites into the cages, the beetles became frantic in their movements, running in every direction. The parasites could be observed clinging to the legs of the beetles and were apparently trying to oviposit in the abdominal sutures and at the junction of the legs and body. The parasites did not appear to mind being run over and carried around by the beetles but seemed intent on gaining hold on the ventral side of the abdomen.

Actual oviposition was not definitely observed and, owing to the chitinous integument of the beetle, it was impossible to dissect them and find the eggs. For this reason the length of the egg stage was not determined. The length of the egg and larval stages combined averaged about 12 days, with extremes of 10 and 18 days.

Large numbers of parasites may infest a single beetle, and as high as 124 larvæ were secured from an individual. The average number of parasites bred from a beetle was about 50. It is interesting to note that the beetles live from 12 to 48 hours after the larvæ leave the body and maintain most of their normal activities up to the time the parasites leave. One female deposited three eggs the same morning that she yielded 124 *Perilitus* larvæ.

The efficiency of this parasite in the field was not definitely established. In 1916, as high as 50 per cent of the beetles collected in August were parasitized, but, from the data at hand, it would seem that the average parasitism is only about 5 or 7 per cent. Of the 932 beetles collected in 1917, not a single one was parasitized.

Physiological Relations

Effect of Humidity.—Most of the species of the genus *Eleodes* are confined to the semi-arid regions of the United States west of the Mississippi River. They reach their greatest abundance, both in species and individuals, in those areas of little rainfall. As has been stated elsewhere in this paper, only three species have been authentically recorded east of Kansas. Owing to the wide distribution of *E. tricostata*, however, it is probably not as greatly influenced by moisture conditions as most of the species.

In the life-history studies, care had to be taken at all times to keep the cages moderately dry. When adults were placed in cages containing moist soil, oviposition decreased, and when they were placed in cages containing both moist and dry soil, they showed a great preference for the dry soil. The larvæ developed best in a slightly moist soil. When the soil was too wet to crumble nicely, the mortality increased greatly.

Blaisdell (1910, pp. 64–65) makes some interesting observations on the effect of moisture on the adults of *Eleodes* in general. He says that the individuals making up the specific aggregate do not necessarily breed true to any intraspecific degree of sculpturing, as this is wonderfully influenced by environment and food supply. The beetles that develop in an exposed or arid region where the body fluids are reduced to a minimum by evaporation during the latter stages and especially after the pupal skin is shed will have a comparatively smooth form of sculpturing. Conversely, beetles developing in a protected or moist region where the body fluids are conserved will have a more strongly punctured or strongly striate form. The dominant form of sculpturing is therefore determined by seasonal conditions, a hot, dry season producing a large number of the smooth forms and a cold, wet season the more strongly striate and punctured forms. There will also be a varying per cent of intermediate forms produced.

Effect of Light.—The larvæ of *E. tricostata* are negatively phototropic. When placed on the surface of the ground they immediately burrow into the soil. In all the studies so far made, larvæ have never been found on the surface of the ground. The adults, like most of the species of *Eleodes*, are generally nocturnal or crepuscular in their habits. They seek to avoid light in the field by hiding during midday under rocks, logs and manure, and also in burrows of other animals.

Measures of Control

E. tricostata has not as yet become of sufficient economic importance to warrant any extensive experiments on control. The use of poisoned bran was tried, under laboratory conditions, on the adults with good success but the larvæ lived for weeks on such a diet. With most of the injurious forms of *Eleodes*, it has been found possible to control them by summer fallowing the ground. This is a procedure that could be followed in western Kansas to a good advantage. Rotation is also recommended in some cases since the beetles are wingless and move only on foot. Hyslop (1912, p. 87) records his experience in treating seeds with various poisons to destroy the larvæ. Five or six poisons and repellents were used, all with negative results.

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SEASONAL IRREGULARITIES OF THE CODLING MOTH

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This paper includes a brief résumé of the observations that have been made relative to the behavior of the codling moth at Hood River, Oregon, during the years 1914, 1915, 1916 and 1917. The work has been conducted for its applicable value chiefly, in order that the local orchardists might be supplied with first hand information on the seasonal progression of this insect's activities, which would enable them to more intelligently and satisfactorily apply their lead sprays. Not being a major project, the investigation lacks many details that would more clearly demonstrate the very wide seasonal variations in the life-history of this apple insect from one year to another.

The two most important points that have been brought out in this study are, first, the very decided variation in the emergence of the broods from one season to another and its necessary influence on the timing and applying of sprays in order that control may be entirely successful. Secondly, the investigations indicate that sweeping recommendations given out often in the form of spray bulletins from a central or distant station are far from meeting the requirements in codling moth control in the different apple growing sections of the Pacific Northwest where vast ranges of conditions are found at relatively short distances. These ranges, due probably to temperatures, varying on account of altitudinal, coastal and interior influences, are such as to warrant seasonal studies of the insect in the different sections in order that a comprehensive knowledge of the insect's activities be available for the use of orchardists in their control measures. Until such stations of study are maintained we can expect a great deal of trouble from the codling moth in the Northwest. The variation in the life-history of the moth, which influences the timing of sprays, has been found to be of more importance in the control of the second generation of worms than the first brood, as in the case of the latter, conditions which retard vegetative growth usually directly influence insect activity with a result the standard spring applications—usually a combination insecticide and fungicide—can generally be effectively applied by following a prearranged spraying program.

The information gained and the points herein discussed have been obtained through yearly breeding cage studies and field observations of the different stages in the life-cycle of the codling moth. Properly prepared and watched, the breeding cage can be used by the investigator as a good index for the successful timing of sprays in order to get maximum control. However, in the hands of the novice, particularly one who is not very familiar with insect life, information gained from the cage can lead one astray. The writer has found some growers who can draw sound deductions, while for others, the interpretation would prove disastrous.

The breeding cage information gained by the writer during the past four years has on many occasions proved decidedly perplexing, and was only of value when carefully weighed with surrounding general field conditions. As an example of this: In 1915 we observed several moths issuing in the breeding cages as early as April 27, due to the fact that about a week of very warm weather occurred at that time. This was followed by cold, rainy weather during the remainder of the spring. No more moths issued in the cages for nearly a month and no eggs were found until May 28. This is only one of many similar observations. When problems arise that puzzle the trained investigator—who can make deductions of value only upon considering the problem from all angles—the orchardist stands little chance of gaining more than approximate information at best. In the absence of expert advice, however, breeding cage studies on the part of orchardists are to be encouraged. Its maintenance not only keeps them more keenly interested in habits and control but, if carefully attended to, serves as a very good indicator where developments are normal.

Breeding cages employed by the writer have been of two kinds: one a box 14 x 16 x 20 screened in on three sides by ordinary window screening, and the other the actual screening in of the trunks of apple trees which were known to harbor codling moths; in order to insure a good supply, trees were often banded before the brood left the fruit, following which the cages were attached.

For spring study of the insects' development, cages were always prepared and stocked with worms during the fall of the year. In so doing no unnecessary stimuli, showing itself either in the form of increasing or retarding emergence occurred. A much greater variation in the emergence of the moths has been noted where transfers from the tree trunks were made during the spring of the year. The mortality of spring transfers is also much higher, making it often difficult to gather accurate information. To facilitate the stocking of cages, trees were usually banded before the worms left the fruit. Many of the insects will establish themselves in the folds of the burlap, which is used, and

transferred to the cage, without disturbing them, if their cocoons have already been spun. Others can be readily removed from the trunk and be placed in the cages which have been provided with bark, chips and decaying bits of wood in which the larvæ burrow and spin their cocoons. To determine development from some of the worms which have not suffered transferring, worm-infested apples are placed in the cages; these apples are removed as soon as the worms have left the fruit.

The cages are distributed throughout the Valley at different altitudes. Commercial apple orchards are found at heights ranging from 100 to nearly 2,000 feet. The average seasonal variations in the two extremes given, has been found to be from fifteen days to three weeks for the first brood and about ten days for the second. In the emergence of the first brood a very definite progression from the lower to the higher elevations occurs; it is much less pronounced for the second, due probably to the fact that summer temperatures, during the day at least, are more nearly uniform throughout the Valley than are the spring temperatures.

TABLE I—MAXIMUM AND MINIMUM TEMPERATURE RECORDS FOR YEARS 1914-1917 INCLUSIVE, HOOD RIVER, OREGON

	1914		1915		1916		1917	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
April	62	53	64	39	62	39	54	36
May	73	58	65	42	64	41	62	43
June	72	50	74	49	73	46	74	48
July	82	53	78	56	73	50	84	52
August	82	52	84	54	79	52	83	52
September	67	45	..	..	72	45	72	48

As nearly normal orchard conditions as can be determined are taken into consideration when establishing the cages. This particularly refers to sun exposures, wind and rain, that emergence may be as nearly uniform to the surrounding orchard conditions as possible. As far as time has permitted, breeding cage observations and notes have been checked against field observations.

The accompanying table (Table I) summarizes the different points of greatest interest in the life-history of the codling moth during the past four years. In comparing the dates of emergence of the moths of the first brood over this series of years there occurred a variation of a full month and a half. A record was not obtained in 1914 but in 1915 the first moths issued in the cages on April 27. In 1916 this phenomenon occurred on May 26 and in 1917 on June 15. The question that

immediately presents itself is: what factor or group of factors is responsible for this very marked variation. A study of the existing weather conditions during these years assists to a large degree in supplying the answer.

Owing to the fact that the writer did not arrive in Hood River until the middle of July, 1914, observations were not taken relative to the weather conditions during the early season. However, a study of the daily weather report indicates that the temperatures for April, May and June for this year were exceedingly mild, the mean average temperature being much higher than in any of the other three years under consideration, and this is largely due to the fact that the average minimum temperatures were uniformly higher during the three months. The result was that codling moths issued in large numbers early in the season. This was followed by favorable weather conditions for egg deposition and hatching. Mr. G. F. Moznette, who made observations at Hood River on the activities of the codling moth during the spring of 1914, found eggs hatching in large numbers in several orchards on June 5. On this date many of the worms had entered the fruits. Summer weather during July and August continued favorable for development. The first worms were found leaving the apples on June 24; pupæ were noted on July 7 and moths emerged July 19. On July 27 the first eggs of the second brood were found on the fruit. The Station gave out, at this time, notices for growers to begin their spraying operations for the control of the second generation of worms.

In 1915, during the months of April, May and June there was much more fluctuation in the daily temperatures than in the corresponding time during 1914. The average maximum temperature for 1915 was practically the same as for 1914 but the minimum temperatures were very much lower. In 1915, due to this fluctuating daily temperature, breeding cage observations seemed of little importance when correlated with timing of sprays for the control of the first generation of worms. The latter part of April and the first few days of May were very warm resulting in the emergence of numerous moths in the breeding cages on April 27 and the days immediately following. At the time the calyx spray was being applied in an orchard in which the writer was carrying on experimental work many moths were flushed from the trees when the spray was thrown into the foliage. Following the sixth of May and continuing throughout the remainder of the month rainy, cold weather occurred. The influence of these conditions not only prevented emerged moths from depositing eggs but checked—practically stopped.—emergence which had begun on April 27. Eggs of the codling moth were not found until May 28, one month after the emergence of the first insects. These were found plentifully during the month of June and

early in July. The first hatching eggs were noted on May 31. The average maximum temperature during July was about 6 degrees below normal which apparently retarded the development of the insects during this time. The first moths of the second generation issued July 26 and eggs were first noted August 10—14 days after the egg hatching of 1914. Growers were advised to have their spray on by the 12th or 15 days later than was recommended the preceding year.

The year 1916 proved to be one of more irregularities in the habits of the codling moth than of any ever previously studied by the writer. Spring and early summer seasons were very far from normal. The spring and early summer was cold and accompanied by many rainy days, and late summer, though fair weather prevailed, at no time did it become warm. The first moths issued in the breeding cages May 26 or at practically the same time eggs were present on the trees during the two preceding seasons. Emergence of moths was at its height between the 6th and 15th of June. On June 10 the first eggs of the season were observed. Beginning with the 17th of June (at which time egg deposition should have been at its height) rainy weather conditions set in which continued until July 4. During this time temperatures were very low, there being only five days during this period at which time the thermometer registered above 60 degrees at sunset (the theoretical minimum temperature required by the codling moth for the deposition of eggs). Of these five days, three registered 62 degrees. Eggs of the first generation were found present on the fruit as late as the 8th of August but at no time during the summer were they numerous.

Moths of the second generation were found for the first time on August 18, exactly one month later than in 1914 and 22 days later than in 1915. But very few second brood moths appeared in 1916; for the most part but one generation occurred. This definite statement can be made due to results of breeding experiments conducted to determine this point. Those worms which resulted from eggs deposited prior to the cold, rainy weather which extended from June 16 to July 4 produced second generation insects; those insects resulting from eggs deposited following this cold period failed to undergo any changes after they left the fruit and remained as larvæ on the trees until the spring of 1917.

The year 1917 was productive of still different irregularities in codling moth behavior. The past season has been one accompanied by heavy losses in many northwestern apple growing sections due to the great numbers of worms. Hood River was apparently more fortunate than most of the sections in this repsect but nevertheless losses in a good many orchards were serious.

In 1917 the early season was very backward, March, April and May

TABLE II—CODLING MOTH BEHAVIOR FOR THE YEARS 1914–1917 INCLUSIVE, HOOD RIVER, OREGON
(Compiled from Breeding Cage and Field Notes)

1st Moth Emerged	1st Egg Deposited	1st Egg Hatched	Egg Dep. Completed	1st Worms Leave Fruit	First Pupation
First Generation					
.....	.....	.....	July 9	June 24	July 7
April 27	May 28	May 31	July 14	July 14	July 18
May 26	June 10	June 15	August 8	July 25	August 1–8*
June 15	June 25	June 27	July 26	July 20–26	July 26–August 2*
Second Generation					
July 19	July 27	August 2	September 25	September 5	September 20
July 26	August 10	August 12	.....	.....	August 31 (few pupa pres.)
August 18	August 25	August 28	late September	.....	.....
August 3	August 8	August 10	October 16	August 31	.....

*Exact date not obtained.

were quite cold accompanied by many days of rain. This prevailing condition had a very marked influence on plant development; leaf buds on the apple trees did not begin to burst till the first of May. At this time during the years 1914 and 1915 the petals were falling followed shortly by the calyx spray. Even after this late bursting of the foliage, development continued to be very slow owing to the continued low temperatures. The average maximum temperature for the month of May was but 62 degrees. A temperature of 70 degrees was not reached until the last day of the month. With the arrival of June, weather conditions changed; continued warm, settled weather following June 4. The first moths, however, did not emerge in the cages until June 15. This observation was checked up with orchard conditions during this period and no moths were found to have issued under field conditions up to this time. This date was nearly a month and a half later than the first emergence in 1915 and 20 days later than in 1916. From June 15 on, however, activities of the moths progressed at war time speed. Favored with ideal weather conditions, the large numbers of worms which established themselves on the tree trunks and protected locations throughout the summer of 1916 issued as moths and apparently deposited their full quota of eggs. The first eggs were found on June 25, practically one month later than in 1915 and 15 days later than in 1916 which was in itself a late season. Hatching eggs were noted on June 27 and on July 26 or at the same time noted in 1916 worms were found leaving the apples to undergo their normal changes. On August 3 the first moths of the second brood issued and eggs were

noted on August 8, 17 days earlier than in 1916. In other words, codling moth activities started off one and a half months behind that of 1915 and by the time eggs of the second generation were deposited were just two days behind. The first brood of 1917 started off 20 days behind that of 1916 and by the time eggs of the second generation were deposited it had gained 17 days.

Prevailing warm weather continued throughout August, September and October during which time the second brood of insects was very active in 1917. Hatching of the eggs reached its height during the middle and latter part of August but continued until the fruit was harvested. Eggs on the fruit in the boxes were found while checking up experiments as late as October 16. This continued activity made it advisable for our station to recommend an extra moth spray, suggestions for the application of which were given out for September 5.

At this point the question might be asked whether it was not a partial third brood of insects which caused the deposition of eggs found late in October. A series of the earliest matured larvæ of the second generation were caged and their activities watched during the remainder of the season; in not a single instance did pupation occur. A study of this character has been conducted during some of the other seasons but up to the present time no indications of the occurrence of a partial third generation has been observed at Hood River.

As a general practice in the past in most of the sections of the Northwest, spraying for the control of the second generation of worms has been supposed to be necessary between the 25th of July and the first of August. This was the belief of local orchardists at the time the writer began the study of this insect at Hood River. In 1914 the study checked up nicely with these suppositions; the 27th of July being the time recommended for spraying. In 1915 the spray was applied most effectively August 12; in 1916—where it was necessary—August 28; and in 1917 on August 12. In two years out of the four the recommended date for applying the summer application of arsenate of lead was the same; with the extremes there was more than a month's difference. Those of you not entirely familiar with codling moth control might ask the question: What material difference would it make if the spray was applied even 10 or 12 days before egg hatching? The answer would be in terms of obtainable results in ordinary seasons of infestation, the difference between complete control as against one half or even less control. In other words, an application of spray cannot be completely effective during a period, not to exceed 20 days at this time of the year, owing to the rapid growth of the fruit and its necessary partial uncovering. If a spray is applied 10 days in advance of the brood hatch, one half of its complete effectiveness is forfeited at the

time the application is made. Effectiveness in codling moth control rapidly decreases at the end of twenty days. Egg hatching activity, on the other hand, under normal conditions, is usually approaching its height ten to twelve days following the hatching of the first eggs. At this time, then, a maximum need for protection is demanded and the effectiveness of the application of spray is rapidly decreasing. A large percentage of the losses that result and poor control obtained on the part of orchardists can be traced to this source.

The reduction of time of application of a spray to the shortest safe period preceding egg hatching will only be productive of good results. Very close timing, in the case of protracted egg hatching, will often save an extra application of spray and much unnecessary expense. To accomplish this end it is necessary to obtain a very intimate knowledge of the insect's seasonal behavior and demands a careful investigation in the different sections by a thoroughly competent investigator.

It is the belief of the writer that the losses due to the activities of the codling moth in the Northwest can only be reduced to the minimum through the establishment of observation stations in the widely separated apple growing sections. An investigator located in some of these sections during the past year could have saved his community enough to maintain a station for at least twenty-five years.

SOME FACTORS INFLUENCING THE DISTRIBUTION OF PEMPHIGUS BETÆ DOANE IN BEET FIELDS

By Asa C. Maxson, *In charge of Insect Investigation*, The Great Western Sugar Co., Longmont, Colo.

The sugar beet root-louse, *Pemphigus betæ* Doane, presents one of the most serious insect problems which confront the beet sugar industry of the Western States.

The seriousness of this insect's injury immediately becomes apparent when we realize that the difference between the sugar actually produced and what could be produced from the same acreage, were it possible to prevent this injury, amounts to a loss of several hundred thousand dollars annually to the industry.

In the course of his work with this insect, the writer has been continually impressed by the fact that our knowledge of the factors operative in its dispersion and distribution in the sugar beet growing areas of the west is altogether inadequate. This led to the making of a preliminary field survey during the growing season of 1916, it being hoped that something might be learned that would eventually result in the develop-

ment of better means of controlling this pest than we have at the present time.

This work was undertaken for the express purpose of studying the relation of previous crops and the presence of the winter host tree, *Populus angustifolia*, to the degree of infestation.

The areas covered will be known in this report as the Longmont and Eaton territories. The former extended from the foothills of the Rocky Mountains, in Boulder County, eastward a distance of 18 miles, contained 44,800 acres and 410 beet fields. The latter, which is in Weld County, was 14 miles long, lay parallel to the mountains with its western boundary 24 miles to the east of them. This territory contained 32,000 acres and 253 beet fields.

Owing to the topography of the country and the shape of the beet growing areas these territories are naturally divided into sections. The Longmont territory is divided into 3 sections. What will be known as the river section is the most westerly and extends in a narrow strip each side of the St. Vrain River from the foothills to the city of Longmont, a distance of 9 miles. Northeast of this is the central section, a rectangular area 4 miles east and west and 5 miles north and south. East and a little north of the central section is the eastern section. This is also a rectangular area. It is 5 x 6 miles, the 6-mile side running east and west.

The Eaton territory is divided into a north and a south section. The former lies north and west of the town of Eaton. It is rather irregular in shape, being 8 miles north and south with an average width of 3.5 miles. The latter lies south and east of Eaton. North and south it is 6 miles and has an average width of 3.75 miles.

As already stated, the main object in making this survey was to study the relation of previous crops and the presence of the winter host to the degree of infestation. However, it was found that another factor would have to be taken into account in working up the results of the survey, *i. e.*, what the writer calls the "time factor." The effect of this and the "previous crop" and "winter host" factors will be considered in the following pages.

THE TIME FACTOR.—There is no doubt that the original infestation in all beet fields is due either to the hibernating, wingless lice or the spring migrants which come from the winter host. This being the case, the number of infested beets should not change after migration from the trees ceases (which is about August 1 at the latest with us), unless the lice migrate from beet to beet in the field. That this actually takes place is shown by the following observations.

An examination of several beet fields during August and September revealed many wingless lice and pupæ leaving the soil, climbing up the

leaf stems and crawling about on the surface of the ground. This was especially noticeable after the beets had been irrigated. The wetting of the lower levels apparently drove the lice to the surface. During their wanderings many became located on beets which were uninfested up to this time.

In order to ascertain to what degree the infestation increased, 300 beets were pulled once a week from a small plot in the experimental field at Longmont and a record made of the number infested. The first 300 were pulled on August 12, at which time 68 beets out of every 100 were infested. One week later the infestation had reached 75 per cent. By the end of the next week 100 per cent were infested.

The action of this factor makes it impossible to make some very desirable comparisons; however, the survey was made in such a way that many interesting comparisons are possible.

THE PREVIOUS CROP FACTOR.—The fact that rotation is of little or no value in the control of the sugar beet root-louse has long been apparent. The results of this survey seem to prove quite conclusively that rotation is of no value as a means of reducing the losses due to this insect.

In the following tables all fields in the Longmont and Eaton territories are arranged according to the previous crop.

LONGMONT TERRITORY

Previous Crop	*Per Cent Infestation*
Beets	85.70
All grains	82.31
Alfalfa	82.09
Mixed crops	78.71

EATON TERRITORY

Previous Crop	*Per cent Infestation*
Potato	89.6
Alfalfa	83.7
Mixed	82.4
Beets	81.0
All grains	79.5

A comparison of these tables reveals the fact that the different crops do not hold the same relative place in the two territories. This would appear to more fully prove the correctness of the statement already made that rotation has little if any value as a control for this insect.

THE WINTER HOST FACTOR.—This of all the factors thus far studied appears to be the most active in the spreading of the sugar beet root-louse in northern Colorado. A comparison of the degree of infestation in all fields in those parts of the territorial sections where the narrow-leafed cottonwood trees are most abundant and those parts where these trees are relatively few, results in some very interesting figures.

All along the foothills and in the canons through which the streams

which water the eastern plains make their way out of the mountains great numbers of narrow-leafed cottonwood trees are to be found. Normally these trees are very heavily infested with the gall form of *Pemphigus betæ*. As we go eastward following the water courses, these trees gradually give place to the broad-leafed cottonwood, *Populus occidentalis*. Thus we find that in a strip 100 yards wide passing through the timber belt along the St. Vrain River at the west end of the river section there were 282 narrow-leafed cottonwoods and 6 broad-leafed ones. In a similar strip passing through the center of this section there were 429 narrow-leafed and 30 broad-leafed cottonwoods, while in a strip passing through the eastern portion of the section contained 185 narrow-leafed trees as against 134 broad-leafed ones.

Comparing all fields in the western half of this section with those in the eastern, we find that of those of the former portion 100 per cent have an infestation of over 70 per cent and of those of the latter but 97.5 per cent have an infestation of 70 per cent or above.

When we compare all fields within one-half mile of the river with all those more than this distance from it we find that those nearest the river and the narrow-leafed cottonwood trees in the timber belt along it have the heaviest infestation. Of the beets in those fields within the one-half mile limit, 87.07 per cent were above 90 per cent infested while of those in the fields outside of the one-half mile limit but 76.75 per cent were infested to a like degree.

An examination of the central section of the Longmont territory brings out the relation of the winter host and the infestation still more strongly than the preceding.

In the western half of this territory there are 244 host trees and in the eastern half but 25. The per cent of all fields in the two halves of this section which have an infestation of over 70 per cent was 46.6 for the western and 35.7 for the eastern half. If we divide this section into halves by drawing a line from east to west, we find that the per cent of fields with an infestation of over 70 per cent is 56.6 for the north and 34.2 for the south half. There are 187 narrow-leafed trees in the north half and but 82 in the south. Now if we place all fields in this territory into two groups, one including all fields within one-half mile of narrow-leafed cottonwoods and the other including all fields at a greater distance from these trees, we find that of those within the one-half mile limit 46.42 per cent have an infestation of over 70 per cent while of those outside this limit but 36.95 per cent are infested to this degree.

Likewise in the eastern section 69.7 per cent of all fields in the west half, with 571 narrow-leafed trees, have an infestation of over 80 per

cent while of those in the east half where there are but 22 narrow-leafed trees, 65.96 per cent have a like infestation.

In the north half of this territory there are 156 narrow-leafed cottonwood trees and in the south half 437. Of the fields in these halves 78.6 per cent of those in the north and 84.6 per cent of those in the south half have an infestation of over 70 per cent.

If we compare all fields within one-half mile of narrow-leafed trees with all those from one-half to three-fourths and all over three-fourths mile of these trees we find 78.57 per cent, 60 per cent and 54.76 per cent respectively of the fields in the three zones have an infestation of over 80 per cent.

In making similar comparisons in the Eaton territory we find the same higher degree of infestation in fields within one-half mile of narrow-leafed cottonwood trees.

We also find that the western halves of both the north and south sections of this territory carry a heavier infestation than the eastern halves. In these sections it cannot be due to trees within the territories, as the northern section is nearly treeless and contains but one narrow-leafed cottonwood which is near the southwest corner of the section.

The south section has 46 trees of this species, 41 of which are in the southwest corner and five near the southeast corner. When the survey was made no galls of *Pemphigus betæ* were found on any of these trees, most of which were small second growth stock or sprouts coming up about stumps of larger trees which had been cut down the year previous.

The heavy infestation of the west as compared with the eastern portion of these sections suggests the effect of the wind which is no doubt an active factor in the dissemination of the beet root-louse. Just how far the beet root-louse is carried by the wind has not been determined. During early summer, while the heaviest migration of this insect from the winter host is taking place, the prevailing winds of northern Colorado are westerly. It does not seem unreasonable that these insects might easily be carried from the mountains, many miles out on to the prairies by these winds.

West of the northern section of the Eaton territory there are several miles of practically treeless, unirrigated land. The Cache La Poudre River passes just southwest of the southern section of this territory. Along this stream there is a timber belt of varying width within which there are some narrow-leafed cottonwoods. It is probable that the infestation of the Eaton territory comes largely from these trees if not from the mountains.

This survey has been continued during the present summer in the

Longmont territory over an area of 161,280 acres and in the Sterling territory, which is in the northeast corner of the state on the South Platte River. This latter territory covers an area of 38,400 acres. It is hoped that when the results of this study are worked up some valuable information will be secured.

THE PINK BOLLWORM (GELECHIA GOSSYPIELLA) IN EGYPT

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Seconded for temporary service in Egypt by permission of the Colonial Office

Native Home and Distribution

The pink bollworm appears to be a native of India and the southern Asiatic region. It was introduced into Egypt in badly ginned cotton lint. The importation of cotton from India into Egypt occurred between the years 1903 and 1913. The following table shows the amount of cotton so imported:—

Year	*Quantity in Kilograms*	*Year*	*Quantity in Kilograms*
1903	20,510	1909	31,206
1904	25,827	1910	13,353
1905	9,150	1911	..... *
1906	81,240	1912	10,998
1907	162,000	1913	89,995
1908	21,460		

* No importations.

It was found in 1913 that a very considerable number of cotton seeds occurred in this cotton and that in these seeds considerable numbers of pink bollworms were found.

Since that time cotton seed from Egypt has been imported into Brazil and Mexico and as a result pink bollworm is now established in those countries.

At the present time the pink bollworm is known to occur in: Asia—India, Ceylon, Burmah, Straits Settlements, The Pacific Islands—The Philippines and Hawaiian Islands. Africa—Egypt, Sudan, East and West Africa, Nigeria and Zanzibar. In the Western Hemisphere the pink bollworm now occurs in Mexico and Brazil where it has recently become established as a result of the introduction of Egyptian cotton seed for planting.

Food Plants

In Egypt the pink bollworm is known to attack cotton of all varieties, teel or Indian hemp (*Hibiscus cannabinus*), bahmia or okra (*Hibiscus*

esculentus) and holly-hock (*Althea rosea*). The record of pink bollworm in Egypt being bred from pomegranate is evidently an error and probably resulted from the use of a breeding cage which had formerly been used in connection with gelechia-infested cotton seed for containing a diseased pomegranate.

In India, the pink bollworm is stated to feed upon the oily seeds of several trees, not being confined to the same natural order as the cotton plant. In Hawaii, the pink bollworm is said to feed upon the seeds of a Malvaceous tree, the Milo (*Thespesia populnea*).

The egg of the pink bollworm is very small and inconspicuous. The eggs are deposited singly or in groups not often exceeding four or five together. They are laid on the food plant of the larva, the preferred situation on the cotton plant being on the boll.

Life-History and Habits

The duration of the egg stage is some four to ten days, after which the eggs hatch and the young larvæ issue.

The larva at first is yellowish-white in color with brown head and brown thoracic shield. Later, the body of the larva becomes tinged with pink, this pink color being deposited principally in broad bands across the back and extending down upon the sides. In well colored specimens the whole body appears pinkish.

When first hatched the larva proceeds to tunnel into the boll and to penetrate into the interior of the seed. The duration of the larval stage occupies, in summer, about 20 to 30 days. During its life, the larva probably consumes more than the contents of one seed, but usually its feeding is all done within one boll. When very young bolls or flower buds are attacked they are entirely destroyed; very young seeds are also completely destroyed, while the seeds which are attacked at a later stage of their growth may be only partly consumed.

The full-grown larva spins its cocoon and enters the pupal stage either in the boll or at the base of the boll protected by the bract, or, most often, they descend to the ground and pupate amongst the particles of soil, bits of leaf, fallen flowers or other loose material on the surface. The pupal stage occupies about 10 to 12 days, after which the moth emerges.

Two or three days after the emergence of the moth, egg laying begins. It is probable that this extends over only a few days more, the whole life of the moth not exceeding two or three weeks under ordinary conditions.

The whole life-cycle occupies some four to five weeks at that period when the temperature and the condition of the plant is most suitable for the development of the insect. Later in the season when the

weather is getting cooler and the cotton plants are ripening, this time is somewhat extended.

The moths are very rarely to be seen in the fields, although they may be there in enormous numbers. They hide during the day and it is practically impossible to disturb them into flight. At night, probably in the two or three hours immediately following sunset, they are active. It is at this time that feeding, pairing of the sexes and egg laying take place.

In Egypt, experiments have shown that the moth is attracted to light. In Hawaii, Mr. August Busck found that the moth was not attracted to light.

The following tables give the figures showing the number of moths captured by single light traps in two different situations. Light traps in the field, however, have not given any results in the control of attacks by this insect.

TABLE GIVING NUMBERS OF GELECHIA MOTHS CAPTURED IN LIGHT TRAP IN INSECTARY AT MINISTRY OF AGRICULTURE, FROM COTTON BOLLS, IN HEAP ON THE GROUND AND IN TRAYS, FROM APRIL 2 ONWARD. THE TRAYS AND BOLLS CONTAINED IN THEM WERE REMOVED MAY 3 TO ANOTHER ROOM. FROM MAY 4 THE TRAP WAS ALTERNATED IN FOUR-DAY PERIODS BETWEEN NO. 1 ROOM CONTAINING HEAP ON THE GROUND AND NO. 2 ROOM CONTAINING BOLLS IN TRAYS.

Day of Month	April	May		June		July		August	
		1	2	1	2	1	2	1	2
1	No light	No light experiments with baits		..	3	2	..	26	..
2	68			..	1	2	..	15	..
3	33			..	1	..	0	13	..
4	41	41	..	..	1	..	2	..	0
5	20	58	..	28	..	..	1	..	1
6	90	69	..	9	..	..	1	..	1
7		60	..	9	..	2	..	..	4
8	54	..	9	11	..	3	..	..	0
9	42	..	3	..	1	1	..	54	..
10	45	..	3	..	1	6	..	35	..
11	73	..	4	..	1	..	0	34	..
12	50	120	..	..	0	..	0	37	..
13	88	45	..	0	..	..	1	..	1
14		46	..	13	..	..	1	..	2
15		60	..	7	..	9	..	..	3
16	250	..	2	..	..	4	..	..	0
17		..	2	..	0	4	..	81	..
18	150	..	2	..	2	7	..	30	..
19	103	..	3	..	0	..	1	38	..
20	93	84	..	..	0	..	2	29	..
21		27	..	13	..	..	1	..	0
22	167	19	..	5	..	..	1	..	2
23	254	53	..	..	..	8	..	..	1
24	331	..	0	3	..	11	..	..	1
25	300	..	1	..	0	15	..	97	..
26	168	..	0	..	3	13	..	35	..
27	10	..	0	..	0	..	1	40	..
28	50	79	..	..	0	..	0	32	..
29	72	18	..	5	..	..	0	..	0
30	50	19	..	2	..	..	1	..	0
31	..	19	..	..	..	51	..	..	1
									1
Total	2,602	827	29	105	14	138	13	596	18

The light trap used in obtaining the catches recorded in both these tables consisted of an electric light bulb suspended above a pan of

water with a film of kerosene on it. The surface of the water was about 3 feet above the floor level.

TABLE GIVING NUMBERS OF MOTHS CAUGHT IN LIGHT TRAP IN LARGE COTTON SEED STORE AT ALEXANDRIA IN 1917

Date	Moths	Date	Moths
June 21	26	July 13	97
June 22	20	July 14	107
June 23	15	July 15	236
June 25	57	July 16	
June 26	32	July 17	137
June 27	26	July 18	180
June 28	20	July 19	180
June 29	18	July 20	800
June 30	38	July 21	
July 1	65	July 22	
July 2		July 23	
July 3	20	July 24	80
July 4	26	July 25	60
July 5	28	July 26	40
July 6	28	July 27	40
July 8	52	July 28	27
July 9		July 29	20
July 10	68	July 30	
July 11	72	July 31	12
July 12	80	August 1	5

The seed store at Alexandria in which the light trap catches were made, as recorded in the preceding table, was emptied of seed on August 4. New seed from Upper Egypt and the Fayoum began to arrive in this store on August 15. This seed represents the first picking, in 1917, in certain districts.

The numbers of moths caught by the traps each night remained at about the same figures, that is, from 2 or 3 to 15 or 20 until September 1, when the numbers showed a distinct use. In the interval from August 15 to September 1, the emerging moths were probably from scattered seed and pupæ which had been formed between planks in the floor and in crevices in the walls and these represented the resting-stage larvæ from the previous season.

The great increase in numbers, after September 1, was due to the emergence of moths from the short cycle larvæ of the 1917 crop.

The following figures give the catches for each night. It will be noted that on the night of September 11–12 there was no light, and the trap caught only 8 moths, the windows of the seed store being closed. Closing the windows or leaving them open during the night does not seem definitely to affect the catch in the trap.

THE RESTING STAGE

The most important feature in the life-history of this insect is what is called the resting stage of the larva. This resting stage appears to be an adaptation of the insect to its environment. For some reason or in response to some stimulus which is not at present understood, certain of the larvæ, after becoming full grown, spin a special kind of cocoon

TABLE SHOWING CATCHES IN LIGHT TRAP IN SEED STORE* AT ALEXANDRIA, SEPTEMBER 1-17. NEW SEED OF 1917 CROP BEGAN TO ARRIVE IN THIS STORE AUGUST 15

Date, 1917, Morning of	Number of Moths	Windows Open or Closed at Night
September 1	32	.....
September 2	265	.....
September 3	.....	.....
September 4	191	Open
September 5	184	Open
September 6	318	Open
September 7	943	Closed
September 8	2,470	Closed
September 9	4,500	Closed
September 10	7,960	Closed
September 11	5,500	Closed
September 12	8	Closed
September 13	6,060	Closed
September 14	5,760	Open
September 15	2,800	Closed
September 16	5,500	Open
September 17		

*The windows in this seed store were open all day and every day for ventilation. They were closed at night, all through the summer, until September 4.

in which they pass a period of time, varying greatly in length, after which they come out and spin the ordinary cocoon in which the pupa is formed.

In the early part of the season nearly all the larvæ proceed at once to pupate and complete their development. As the season advances an increasing number of them enters the resting stage until, at the end of the season, nearly all follow this course.

It is in the resting stage that the insect passes through the winter or through the period between one crop of cotton and the next, and it is consequently in this condition that it offers the best opportunity for methods of control to be applied.

The eggs are very small and inconspicuous, and the egg stage is short, the larvæ spend all their existence within the tissues of the plant, the pupa is small, well hidden, and occupies a short period of time and the moths are very difficult to find even when they are very abundant. None of these stages offer any satisfactory opportunity for control methods except during that part of the larval life which is called the resting stage.

Resting-stage larvæ are mostly to be found within the cotton seeds. These seeds may be in the seed cotton which is removed from the field as the crop, or they may be in the seeds in bolls which are left attached to the plants or scattered on the ground after the crop is removed. Often two or more seeds are fastened together by the larva in such a way as to allow of its passage from one to another. The presence of "double" seeds is a sure indication of attack by the pink bollworm, but many resting larvæ occur in single seeds. Double seeds are found in the seed cotton, in cotton seed, and in the bolls left in the field after the crop is harvested.

For the control of this insect it is necessary to destroy the resting-stage larvæ at the end of the cotton season. This work falls naturally under two headings—the destruction of all bolls left in the field after the crop is harvested and the destruction of the larvæ in the cotton seed after the cotton is ginned.

Control Measures

In Egypt a law has been passed requiring the destruction of the bolls on the plants and of all that may have fallen to the ground immediately after the crop is finished. A law has also been passed requiring that every ginnery shall be provided with a suitable machine for the treatment of cotton seed as it leaves the gins, for the destruction of the pink bollworm larvæ in the seed.

On account of the difficulties which arise from the war, in obtaining the necessary machinery, this law has not yet been put into force. Experiments have been made, however, with machinery for the treatment of seed by means of heat and there appears to be no difficulty in killing all the worms in the seed without affecting the quality of the seed either for the purposes of planting or for the production of oil.

The use of hydrocyanic-acid gas and carbon bisulphide does not seem to be practicable under the existing conditions in Egypt. The highly poisonous nature of hydrocyanic-acid gas requires the employment of careful and responsible labor in its application and this is not to be had in the ordinary way in the cotton ginneries in Egypt. Further, it is objected that in such a densely populated country the liberation of large quantities of poisonous waste gases would be likely to be injurious to public health. Carbon bisulphide, on account of its highly inflammable and almost explosive character, is not suitable for use in close proximity to cotton ginneries where the atmosphere is laden with the fine particles of cotton which, in the event of fire, are also highly inflammable.

As far as Egypt is concerned, hot air seems to be the most suitable agent for the destruction of the pink bollworm in cotton seed at the ginneries.

The pink bollworm campaign which is carried out under the direction of the Ministry of Agriculture has for its object the destruction of the bolls left in the fields after the crop is harvested. The season of 1916–1917 was the first one in which this campaign was well organized and thoroughly carried out. The results obtained from this campaign although not altogether satisfactory have been very useful. A very large proportion of the bolls were destroyed.

The law required that the bolls should be cleaned from the standing

plants and burnt and that all fallen bolls should be collected from the ground and burnt before the cotton plants were cut or pulled.

In cases where this was not done before the prescribed time the cotton sticks were seized and destroyed by the officers of the Ministry of Agriculture. The value of the sticks destroyed in this manner is estimated at L. E. 87,000.[1] In Egypt, the scarcity of fuel gives to the cotton plants a value which they probably possess in no other cotton growing country and it is because of this that attempts are made to have the bolls cleaned from the plants instead of having them uprooted and burnt.

The prospects for the control of the pink bollworm in the future are distinctly hopeful. During the past season much opposition was met with on the part of the ignorant and superstitious peasantry while the village officials failed to give that assistance which might reasonably be expected of them, and in some instances even directly opposed the efforts of the Ministry of Agriculture.

In succeeding years, however, it is to be expected that the peasants will realize more and more the usefulness of this campaign and that the village officials will render valuable assistance. In the past season also, as a result of the war, there was a shortage of English officials and the native subordinate officials were all new to the work and had to be trained in their duties.

When the working of the field campaign has been improved and the ginneries are equipped with suitable machines for the treatment of seed, there is every reason to hope that the pink bollworm will be controlled to such an extent as to impose only normal losses on the cotton industry of Egypt.

There is no hope that the pink bollworm will ever be exterminated and so far as at present known there seems no likelihood of its ever being controlled to a satisfactory extent by its natural enemies.

The Nature and Amount of Loss Caused by the Pink Bollworm

The pink bollworm causes injury and loss to the cotton by injuring the seed and by reducing the amount of lint produced. The quality of the lint is also seriously affected. Young bolls are attacked and completely destroyed, while, when flower buds are attacked, these are destroyed and no flowers produced.

When a seed is attacked at an early stage of its growth not only is the seed completely destroyed, but no lint is produced by it. Later on, seeds may be attacked when they have formed all or part of their lint. In such cases, it is easily seen that a considerable amount of damage

[1] The L. E. = about $5.00.

may be done to the seed without causing very much loss in the amount of lint produced, although its quality may be affected.[1] A certain amount of damage is also caused by the tunnels of the larvæ through the boll. The lint is stained either by the larva or by fungi or bacteria which attack the injured tissues. Another and important injury is that which results in producing a dead or unopened boll or sections of boll. In these, the cotton remains matted, failing to open properly and is often discolored.

The amount of loss resulting from the attacks of the pink bollworm is very difficult to estimate. In Egypt, for something like twenty years past the average yield of cotton per feddan has been steadily decreasing but there has not been, since the advent of the pink bollworm, any acceleration in the rate of this decrease. The crops of the past three or four years have been slightly smaller than those of the previous few years. The following figures show the yield per feddan for the period 1894–1916 and the means of average yields for the last four five-year periods.

TABLE SHOWING AVERAGE YIELD OF COTTON IN EGYPT FOR THE YEARS 1894–1916

Year	Yield in Qantars* per Feddan	Year	Yield in Qantars per Feddan
1894	4.78	1906	4.61
1895	5.27	1907	4.51
1896	5.60	1908	4.12
1897	5.80	1909	3.13
1898	4.98	1910	4.57
1899	5.64	1911	4.31
1900	4.42	1912	4.35
1901	5.10	1913	4.45
1902	4.58	1914	3.67
1903	4.88	1915	4.05
1904	4.39	1916	3.64
1905	3.80		

* The qantar = 99.05 lbs.; the feddan = 1.038 acres.

The means of the average yields for 5-year periods are:

1897–1901	5.09 qantars
1902–1906	4.45 qantars
1907–1911	4.12 qantars
1912–1916	4.03 qantars

There has been a great fluctuation in the price of cotton owing to the war which makes it extremely difficult to place a money value on the losses caused by the pink bollworm. It would appear, however, from

[1] Attacked seeds lose in weight: They may be entirely destroyed, or may be injured in varying amounts, some, although attacked, being nearly of full weight and producing almost a normal amount of lint.

Another form of injury by the pink bollworm is the loss in weight of seed, in weight of lint, in germination of seed and in quality of lint in the case of unattacked seeds in locules in which other seeds have been attacked.

figures already at hand that the losses resulting from the attacks of this insect may be taken at 10 per cent of the total crop of cotton in Egypt during the past two or three seasons. If this is calculated on the amount and value of last season's crop (1916) we get the following figures:

The total crop of cotton was about 6,000,000 qantars, 10 per cent of which would amount to 600,000 qantars. The average price per qantar for the season may be taken as between 30–40 dollars.[1] At the former price this would mean a loss of L. E. 3,600,000 and at the latter a loss of L. E. 4,800,000. These figures are probably under rather than over the amount of this loss, but, whether they are accurate or not they indicate, strikingly, the very large toll which this insect takes from the cotton industry of the country, and they should serve as a warning to any country in which the pink bollworm does not occur to take every precaution against its introduction.

Natural Enemies

The natural enemies of the pink bollworm do not occur in sufficient numbers or at the right time of the year to exercise any great degree of control over this pest in Egypt.

The insects known to be parasitic or predaceous on the pink bollworm are:

Pimpla roborator, *Chelonella sulcata*, *Rhogas kitcheneri*, a Pteromalid and *Pediculoides ventricosus*.

Pimpla roborator is a general parasite in Egypt. It appears to attack the pink bollworm only late in the season, too late in fact to exercise any control over the amount of damage to the cotton in that season. The practice of burning the bolls left after the cotton is harvested destroys large numbers of this parasite. This is the only parasitic insect which has been bred in large numbers from the pink bollworm.

Chelonella sulcata at present is known in Egypt only as a parasite of *Gelechia gossypiella* and has been known in this country only since the advent of this pest. Up to the present time, it has not been recorded in large numbers.

Rhogas kitcheneri and the small Pteromalid—*Pteromalus* sp., are general parasites which are known at times to attack the pink bollworm.

Pediculoides ventricosus sometimes occurs in great abundance in cotton seed stores and causes the death of large numbers of Gelechia larvæ. There is no certainty that this mite is capable of penetrating into infested single or double seeds containing resting-stage larvæ if nothing has happened to render the union between the double seeds

[1] The dollar = 20 piastres tarif = 1/1 of the Egyptian pound (L. E.).

or the covering over the entrance to the infested single seed less impenetrable than they were made by the larvæ. The action of the cotton gins may result in loosening the silk spun by the larvæ sufficiently to allow for the entrance of the mites.

Any larvæ that come out of the seed in a mass of seed where Pediculoides occurs abundantly are almost certain to be attacked and killed by this mite, especially late in the season.

The two principal natural enemies are then Pimpla and Pediculoides. Pimpla occurs in some numbers but the bollworm campaign in Egypt should result in all the bolls remaining in the field after the crop being destroyed before the time of the greatest emergence of the parasite, and Pediculoides occurs in numbers only in the storehouses later in the season. When the ginneries are equipped with machines for treating the seed as it leaves the gins, the predaceous mite will cease to be of any importance in connection with the control of pink bollworm in cotton seed.

NOTES ON THE WOOLLY APHIS

By Geo. G. Becker, *Fayetteville, Ark.*

Owing to the war and to the uncertainty of concluding investigations as planned, the writer is submitting in this paper the results of investigations with the woolly aphis, *Eriosoma lanigera* Haus., which had as their aim (1) the working out of the life-history of the insect in the Ozarks, (2) studying the relative immunity of various hosts of this insect and of the relationship of these hosts to the species, (3) studying the immunity of Northern Spy stock to the attacks of this species, and (4) determining whether *Eriosoma crataegi* Oestlund is a synonym of *Eriosoma lanigera* Hausmann.

In the Ozarks the species winters on elm in the egg stage and on the roots of apple and in wounds, knots and rough places on the trunk above the ground, of apple and Cratægus as apterous viviparіæ. The occurrence of overwintering apterous viviparіæ above ground on apple or Cratægus is uncommon in this latitude as the aphids seem unable to withstand the low temperatures.

The overwintering eggs on elm probably hatch sometime between the first and the middle of March. In 1916 we found stem-mothers in about the third instar by the 30th of March. At this time the buds, with the exception of the infested ones, had not pushed through.

The second generation begins to make its appearance by the first of April. In 1915 a stem-mother was found on April 20 with about 20 or more young, in 1916 we found a stem-mother on April 6 with

about 15 young and in 1917 we found stem-mothers on April 14 with colonies of young.

The third generation probably makes its appearance a little after the middle of April or possibly even sooner.

In 1915 we observed the mature winged individuals of this generation on May 5. In 1916 we observed a colony on May 12 in which 25–50 per cent of the individuals were winged. In 1917 we found the first winged individuals as early as April 27. Under optimum conditions winged individuals from elm might be found from this time on until nearly the last of July. We have found them as late as July 21. Parasites usually cut this generation short so that under normal conditions it is difficult to find the species on elm after the first week of June.

We have not worked out the number of generations of aerial apterous viviparіæ occurring on Cratægus and apple. Fall migrants make their first appearance with us by the middle of September and in favorable seasons may be found as late as the middle of November. There would thus be a period of five months between the appearance of the first spring migrants and the first fall migrants and a period of four months between the last spring migrants and the first fall migrants. If the aerial viviparіæ mature in the same time that the root forms mature (15–25 days), there would certainly be time for the development of more than two generations as recorded for Maine by Miss Patch[1] and for Vienna, Va., by A. C. Baker.[2]

On the roots of apple the apterous viviparіæ become active by the first of March and continue active until along in November. From the data which we have, this would make it possible for six to twelve generations to develop during the course of a year.

Experiments with Spring Migrants

With a view of determining whether the young of individual migrants would establish on either elm, Cratægus or apple, a series of experiments was begun in which some of the young of each migrant tested was placed on each of the hosts. A safer and more satisfactory method of distributing the young consisted in transferring the migrant from host to host and permitting her to deposit young on each. We found that once a migrant begins to deposit young she usually continues to deposit them in rapid succession until exhausted.

In no case did the offspring of the migrants find elm congenial. In view of the fact that many elms are immune to the insect and that

[1] Maine Agricultural Experiment Station Buls. 220 (1913) and 256 (1916).

[2] Report No. 101, U. S. Department of Agriculture, Office of the Secretary, 1915.

on trees not immune aphids establish only under peculiarly favorable conditions, the experiments with elm cannot be regarded as satisfactory.

In these and subsequent experiments young seedling apple trees and young seedlings of *Cratægus crus galli* were used. Following are the results of experiments with apple and Cratægus.

TABLE I

	No. Migrants Tested	No. whose Young Est. on Both Hosts	No. whose Young Est. on Apple Only	No. whose Young Est. on Cratægus Only
1915	12	4	1	4
1916	5	0	1	0
1917	18	0	16	0

The above does not give us as much data as we would like but these tests along with other tests not recorded in this paper show the marked immunity of Cratægus as compared with apple. The difference in the results of the three seasons suggests that in addition to an inherent immunity, Cratægus may have a conditional immunity depending upon the season. This is further suggested by our experiments with Cratægus seedlings.

Our spring migrants seemed to be slightly more prolific than Baker's, averaging usually from 7 to 8 per female instead of 6 as reported by Baker for Vienna, Va. One individual under our observation deposited 19 young. Another deposited 18.

EXPERIMENTS WITH ELM

In our observations on elm we were impressed at the earliness with which the stimulative effect of the aphids affected the leaves. It appeared that the aphids must have attacked the leaves almost before they had pushed through the bud or at least just as soon as enough was through for them to work on. At any rate the attacked leaves pushed through and curled at once before the normal buds had pushed out. Terminals where embryo colonies were forming were conspicuous on the trees before the normal buds had burst. In the accompanying plate are pictures of normal and infested buds which were collected from the same tree and at the same time, April 6, 1917.

The difficulty which Baker had in getting this insect to establish on elm was witnessed by us. We tried repeatedly to establish second and third generation larvæ on various potted elms but without success. It was noticed on our campus that there was a marked variation in the immunity of various elms to this insect. Near our insectary we have noticed an elm to be infested every year for the last five years

and during the same time numbers of elms which are near it have never been observed to be infested.

It appeared from general observation that backwardness of growth was associated with susceptibility to the attacks of the insect. To verify this, 35 elms were examined at random. They were classified according to their size and were rated as advanced, medium and backward, according to the degree of their advancement at the date of the observation, April 8, 1917. The results of the observations appear in Table II.

TABLE II

Circum. in Inches	Advanced		Medium		Backward	
	Infested	Uninfested	Infested	Uninfested	Infested	Uninfested
20 and up	1	3	0	0	0	0
10–20	1	1	1	1	2	0
5–10	1	3	2	2	2	2
Under 5	0	5	1	5	1	1
Total	3	12	4	8	5	3

It will be observed that the above seems to bear out this contention. In 1915 we observed a small elm, which had been set out the fall before, to be infested. It was presumably congenial to the insect because it was backward during that season. At any rate it has not been observed to be infested since that time.

EXPERIMENTS WITH CRATÆGUS

Many negative results in attempting to get aphids to establish on Cratægus led us to undertake some experiments with a view of determining to what extent this host was immune to the species. Young Cratægus seedlings were used in these tests. Five aphids were applied at a time and we tried to make 10 transfers, making a total of 50 aphids, to each seedling before placing it aside as immune. The aphids used were secured from infested Cratægus plants. The results of these tests appear in Table III.

It will be observed that the first four seedlings tested took colonies. In view of the difficulty of getting colonies to establish later in the season it would appear that the hardening of the tissues would be a condition which would bring about immunity. The seedlings used in experiments Ca–C17 to Ca–C23 inclusive had been used earlier in the season in the Aa–C series (Table IV), and in those tests were not acceptable to the aphids. They were subsequently cut back and watered with manure water until tender shoots were produced. Under these conditions two of the seedlings were acceptable to the Cratægus aphids.

TABLE III

Exp. No.	Duration of Experiment	Transfers		Results
		No.	Total Aphids Applied	
Ca-C1	7/2–10/15	1	5	Colony
Ca-C2	7/2–11/1	1	5	Colony
Ca-C3	7/2–8/5	6	30	Colony
Ca-C4	7/6–8/7	9	45	Colony
Ca-C5	7/18–8/1	9	45	None established
Ca-C6	7/18–8/1	10	50	None established
Ca-C7	7/18–8/1	10	50	None established
Ca-C8	7/18–7/21	2	10	Established
Ca-C9	7/18–7/21	3	15	None established
Ca-C10	7/18–8/1	10	50	None established
Ca-C11	7/18–8/1	10	50	None established
Ca-C12	8/1–8/17	12	60	None established
Ca-C13	8/1–8/17	9	45	None established
Ca-C14	8/1–8/17	11	55	None established
Ca-C15	8/1–8/17	9	45	None established
Ca-C16	8/1–8/17	9	45	None established
Ca-C17	8/3–9/14	6	30	None established
Ca-C18	8/3–8/15	1	5	One established
Ca-C19	8/3–9/14	12	60	None established
Ca-C20	8/3–8/15	1	5	Five established
Ca-C21	8/3–9/14	5	25	None established
Ca-C22	8/3–9/14	14	70	None established
Ca-C23	8/3–9/11	5	25	None established
Ca-C24	8/23–9/14	1	5	Colony
Ca-C25	8/23–9/14	2	10	None established
Ca-C26	8/23–9/14	7	35	None established

From these experiments and from our general experience with the species we conclude;

(1) That through being continuously subjected to the attacks of the woolly aphis Cratægus has acquired a strong immunity against this pest.

(2) That this immunity is inherent or it may be conditional, depending upon factors which influence the character of its growth.

EXPERIMENTS IN TRANSFERRING CRATÆGUS APHIDS TO APPLE AND VICE VERSA

As early as 1910 Hayhurst, thinking that there might be two races of *lanigera*, one on apple and one on Cratægus, made attempts to establish the Cratægus forms on apple and vice versa. His results were all negative. The writer repeated the experiments in 1911 with the same results and in 1913 Mr. Quick, a student assistant, made the same attempt and succeeded in getting a few Cratægus aphids to establish imperfectly on apple. In view of the immunity of most Cratægus seedlings at the time (in late summer), when all of these tests were made, the results were not surprising.

In 1917 Mr. William Lee, a student assistant working under the writer's direction, repeated the tests and included in his experiments Cratægus seedlings which he had previously found to be congenial to Cratægus aphids. His results are given in Table IV. Aa–C17 to

Aa–C23 inclusive were found to be congenial to Cratægus forms in the Ca–C tests (Table III). Under "remarks" is given the number of these seedlings in the Ca–C tests of Table III.

TABLE IV

Exp. No.	Duration of Experiment	Transfers		Results	Remarks
		No.	Total Aphids Applied		
Aa–C2	6/15–7/12	10	50	None established	....
Aa–C3	6/15–7/12	12	60	None established	....
Aa–C4	6/15–7/12	12	60	None established	....
Aa–C5	6/15–7/12	13	65	None established	....
Aa–C6	6/15–7/12	11	55	None established	....
Aa–C7	7/13–7/26	10	50	None established	....
Aa–C8	7/13–7/26	10	50	None established	....
Aa–C9	7/13–7/26	11	55	None established	....
Aa–C10	7/13–7/26	10	50	None established	....
Aa–C11	7/13–7/26	11	55	None established	....
Aa–C12	7/20–7/31	10	50	None established	....
Aa–C13	7/20–7/31	10	50	None established	....
Aa–C14	7/20–7/31	10	50	None established	....
Aa–C15	7/20–7/31	10	50	None established	....
Aa–C16	7/20–7/31	10	50	None established	....
Aa–C17	7/31–8/14	18	83	None established	Was Ca–C3
Aa–C18	8/6–8/23	4	20	Colony	Was Ca–C8
Aa–C19	8/15–9/14	13	65	None established	Was Ca–C16
Aa–C20	8/15–11/15	1	5	Colony	Was Ca–C20
Aa–C21	9/14–10/5	2	25	None established	Was Ca–C24
Aa–C22	10/5–10/13	1	20	None established	Was Ca–C25
Aa–C23	10/15–11/14	2	35	8 established	Was Ca–C1

It should be stated in the case of Aa–C23, which was Ca–C1 of Table III, that it was brought into the tests at a time when it was beginning to shed its leaves. Aphids established on it and produced young though the latter did not establish. When the latter were born practically all the leaves had been shed and the tissues are bound to have hardened.

Further trials were made by attempting to establish apterous viviparіæ from Cratægus on apple with the results indicated in Table V.

TABLE V

Exp. No.	Duration of Experiment	Transfers		Results
		No.	Total Aphids Applied	
Ca–A1	7/16–9/14	18	88	None established
Ca–A2	8/2–9/14	12	60	None established
Ca–A3	8/2–11/1	13	65	Colony
Ca–A4	8/2–9/14	18	90	None established
Ca–A5	8/2–11/1	14	66	Colony
Ca–A6	10/15–11/1	2	3	None established

The apple seedlings used in the tests given in Table V were tested and found to be congenial to apple aphids.

The results of our transfer experiments lead us to the conclusion:

(1) That apterous viviparіæ from apple can establish on Cratægus though they do not establish on that host as readily as they do on apple.

(2) That apterous viviparіæ from Cratægus can establish on apple though they apparently do not establish as readily on that host as do the apterous viviparіæ from apple.

Northern Spy Immunity

Aside from experiments undertaken with Northern Spy roots no definite experiments were undertaken to see to what extent different apple seedlings were immune to the woolly aphis. It might be stated however, from general experience, that we noticed a difference in the degree of immunity of different apple seedlings. Generally speaking, though, we had no difficulty in establishing either the offspring of spring migrants or of apterous viviparіæ from other apple seedlings on this host.

In these tests pieces of Northern Spy root were placed in tin salve boxes and handled in the same manner as described for our experiments with the apple root forms. Five aphids were applied to each piece of root and when these had died another attempt was made to establish a colony by adding five more aphids. The aphids used were usually of the first instar and were taken from crab roots.

We made 161 attempts to establish colonies on Northern Spy roots, using a total of 805 aphids. Of the 161 attempts we got colonies to establish temporarily in 16 instances. In two of the trials we succeeded in getting the aphids to establish long enough to produce young but the latter failed to establish permanently. In no case did we succeed in getting permanent colonies to establish on Northern Spy roots.

As a check against these results we made 51 trials to establish aphids on crab roots, using in the tests 255 aphids. Twenty-seven of the trials yielded colonies. In most instances these colonies were permanent.

Most of these tests were made by my student assistants, Messrs. W. D. Merrill and Wm. M. Lee, and their notes repeatedly call attention to the sickly condition of the temporary colonies on Northern Spy as compared with the thrifty colonies on crab roots.

From these tests we conclude that Northern Spy is immune to the woolly aphis and that, when aphids do establish temporarily, it is due to the fact that they are exceptionally hardy rather than the fact that the host is congenial.

Experiments with Apple Root Forms

Experiments were begun with a view of working out the duration of the instars, number of young per female, longevity, number of generations per season, etc., of the apple root forms. We got satisfactory results by using tin salve boxes in the bottom of which we poured paraffin mixed with lamp black. This enabled us to detect aphids or exuviæ which had fallen on the bottom of the box. Pieces of root were wrapped at one end with moist cotton batting and the other end was left exposed for the aphids. The boxes were sunk in soil out of doors and were covered with a board.

Records of 40 aphids made by my predecessor, Mr. Paul Hayhurst, during March and April of 1910 are summarized in Table VI.

The days for each instar are given. Duration of the fifth instar is practically the same as the period of reproduction as aphids almost invariably begin to reproduce on the same day that they moult the fourth time. The number of days from birth to the first young will therefore generally be the same as the combined number of days of the first four instars. The age at death is expressed in days.

Table VI

	Days 1st Instar	Days 2nd Instar	Days 3rd Instar	Days 4th Instar	Days 5th Instar	Days to Young	Max. Yng. per Day	Total Young	Age at Death
Average.....	7.3	3.9	3.2	3.8	22.6	18.8	11.5	86.3	49.2
Range.....	3-14	2-7	1-6	1-8	5-47	15-25	2-23	8-167	21-59

If the aphids develop on the roots of apple under normal conditions as well as in the salve boxes and if later generations develop as rapidly as the generations in March and April, it would appear that it would be possible for 6 to 12 generations to develop from March to November, which period is the period of activity of the root forms in this latitude.

Experiments with Fall Migrants

In 1915, 1916 and 1917 we made numerous attempts to get fall migrants to deposit sexuparіæ on Cratægus, apple and elm seedlings under cage conditions. Migrants were placed in cages of varying sizes with these seedlings and with large limbs from elms but we failed to get the sexed forms in 1915 and 1916. During the same period we also tried placing seedlings of its three hosts in the window and releasing the migrants in a dark corner of the laboratory. Although the migrants made their way to the seedlings they failed to deposit young on them. In 1917 we succeeded in getting migrants to deposit the sexed forms by confining them in large vials and under glass cylinders with rough pieces of elm bark, however, we failed to get any eggs from the sexed forms,

Eriosoma cratægi Oestlund

Mounts were made of the fall migrants of *Eriosoma lanigera* secured from different sources (apple and Cratægus), with a view of determining the effect of the host on the antennæ of the aphids. The results are tabulated in Table VII. The table gives the measurements of the segments in mm. The number of annulations of the segments is also given.

The following explanation is given for the slide numbers.

Slide 1.—From control colony on apple reared from a spring migrant in 1917.

Slide 2.—From a control colony on Cratægus reared from a spring migrant in 1915.

Slides 3 and 4.—From colonies on potted apple trees which were presumably started by spring migrants in 1917.

Slide 5.—From the same source as Slide 2.

Slide 6.—From apple colony established by transferring apterous viviparіæ from Cratægus in 1917. (Colony Ca–A5 of Table V.)

Slides 7 to 11 inclusive.—From Cratægus colonies established by transferring apterous viviparіæ from apple in 1917. (Colonies Aa–C18 and Aa–C20 of Table IV.)

TABLE VII

Slide No.	I	II	III		IV		V		VI	
	Meas. in mm.	Meas. in mm.	Meas. in mm.	An. No.	Meas. in mm.	An. No.	Meas. in mm.	An. No.	Meas. in mm.	An. No.
1	.068	.073	.416	22	.124	5	.124	7	.088	0
1	.061	.065	.415	26	.112	6	.112	6	.084	0
2	.061	.064	.432	27	.124	5	.146	8	.085	1
3	.059	.056	.320	16	.108	4	.112	5	.085	2
3	....	.064	.335	18	.072	3	.120	5	.092	1
3	.064	.064	.382	20	.130	7	.126	6	.096	2
3	....	....	.365	20	.131	6	.128	5	.092	0
4	.056	.064	.400	21	.112	4	.128	7	.088	0
4	....	.064	.400	20	.128	5	.120	5	.096	1
4	.058	.066	.365	18	.112	5	.115	5	.086	0
5	.059	.060	.455	28	.120	6	.141	7	.096	2
5	.064	.064	.440	27	.112	6	.120	7	.104	2
5	....	.056	.462	29	.120	6	.144	8	.112	2
6	....	.051	.342	20	.096	3	.110	5	.096	1
6	.056	.053	.343	20	.120	4	.123	6	.072	1
6	.051	.061	.343	18	.110	3	.123	6	.083	1
6	....	....	....	..	.088	3	.100	5	.075	2
7	....	.056	.375	24	.120	5	.128	6	.112	3
8	.051	.051	.400	24	.120	7	.131	7	.112	4
8	....	....	.420	25	.131	6	.152	10	.115	3
8	....	....	....	..	.112	5	.152	8	.115	5
9	....	.064	.368	..	.112	7	.148	8	.112	3
9	.064	.064	.405	27	.112	7	.156	8	.112	3
9	.064	.061	.420	27	.135	7	.152	8	.112	4
9	.064	.061	.430	28	.128	7	.152	10	.112	3
10	....	.061	.431	27	.128	6	.160	7	.115	3
10	....	.064	.430	25	.135	7	.160	8	.118	3
11	.056	.056	.430	25	.120	6	.155	8	.096	2
11	....	.056	.440	28	.128	6	.148	9	.112	2

It appears from a study of the 13 antennæ of apple migrants and the 6 antennæ of Cratægus migrants that the antennæ of the latter are usually longer than those of the apple migrants. Especially is this the case in segments III, V and VI. For convenience the writer has

averaged the antennæ of migrants of the two hosts separately and collectively in Table VIII. The wide range of variation in the antennæ of *Eriosoma lanigera* is well shown in the range for the 29 antennæ measured. It is such that it might well embrace the measurements given for *Eriosoma cratægi* by Davis in Volume 3, No. 5 of this JOURNAL.

TABLE VIII

	I	II	III		IV		V		VI	
	Meas. in mm.	Meas. in mm.	Meas. in mm.	An. No.	Meas. in mm.	An. No.	Meas. in mm.	An. No.	Meas. in mm.	An. No.
Thirteen Antennæ from Apple Migrants										
Average.....	.059	.062	.360	20	.111	4	.119	6	.087	1
Minimum.....	.051	.051	.320	16	.088*	3	100	5	.072	0
Maximum.....	.068	.073	.416	22	.131	7	.128	7	.098	2
Sixteen Antennæ from Cratægus Migrants										
Average.....	.060	.060	423	27	.122	6	.147	8	.109	3
Minimum.....	.051	.051	368	24	.112	5	.120	6	.085	0
Maximum.....	.064	.064	.462	29	.135	7	.160	10	.118	5
Thirteen Antennæ from Apple and Sixteen Antennæ from Cratægus Migrants										
Average.....	.060	.061	.389	23	.117	5	.134	7	.099	2
Minimum.....	.051	.051	.320	16	.088*	3	.100	5	.072	0
Maximum.....	.068	.073	.462	29	.135	7	.160	10	.118	5

*The smallest segment IV was on slide 3. It measured .072 but appeared somewhat abnormal.

EXPLANATION OF PLATE 6

1 and 2. Antennæ from migrants out of control colony on apple established from the offspring of a spring migrant.

3. Antenna from fall migrant taken from colony on potted apple tree.

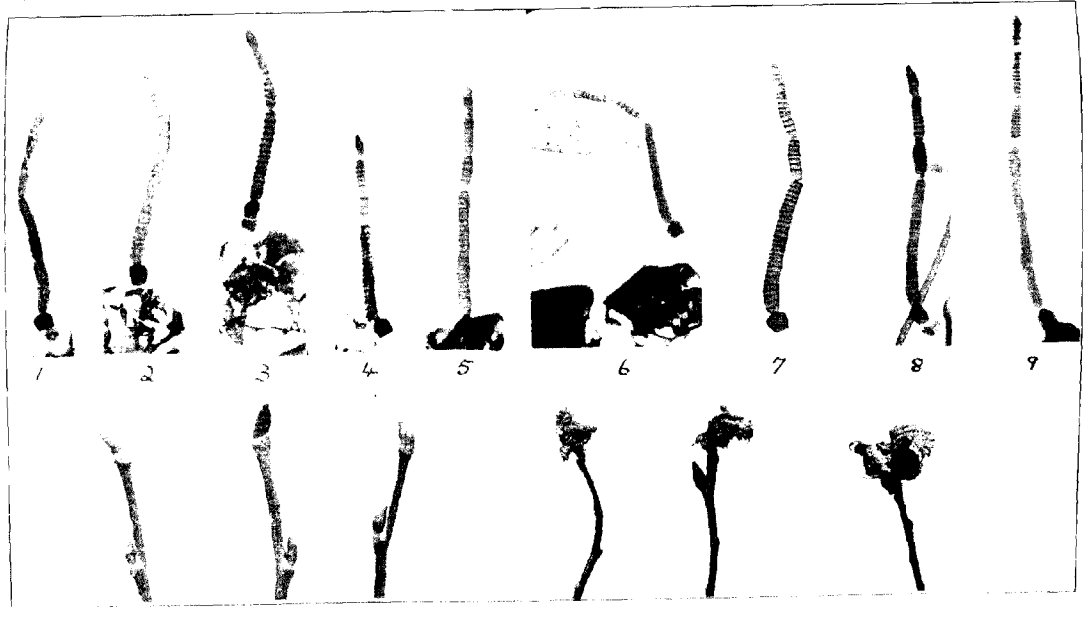
4. Antenna from fall migrant out of colony established on apple with apterous viviparіæ from Cratægus. (Colony Ca–A5 of Table V.)

5. Antenna from fall migrant out of control colony established on Cratægus from spring migrant.

6–8 inclusive. Antennæ from fall migrants out of colonies established on Cratægus with apterous viviparіæ from apple. (Colonies Aa–C18 and Aa–C20 of Table VI.)

9. Antenna of fall migrant of *Eriosoma cratægi* taken from mount loaned me by A. C. Baker.

The two lower pictures represent normal and infested elm buds collected at the same time, April 6, 1917 and from the same tree.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Baker,[1] in suggesting that *Eriosoma cratægi* is a synonym of *Eriosoma lanigera*, pointed out that the principal difference between the species was in segments V and VI which were proportionately longer in the former species. As previously indicated, our data show that these two segments are proportionately longer in our Cratægus reared aphids.

Through the courtesy of Mr. Baker the writer was permitted to examine a mount of *cratægi* migrants. A photograph was taken of a typical antenna of this species and photographs of *lanigera* migrants were made in comparison. All are taken at the same magnification (about 48 X), and are represented in the accompanying plate. It will be noticed that Nos. 5 and 8, antennæ from Cratægus reared aphids, are strikingly similar to the antenna of *cratægi*, figured in 9.

If measurements and structural differences are to be used as a basis for dividing them, it would hardly be possible for us to regard *cratægi* and *lanigera* as two species.

Conclusions

(1) The life-history of *Eriosoma lanigera* in the Ozarks is the same as recorded for Maine and for Vienna, Va., with the exception that there are probably more than two generations of apterous viviparіæ on apple and Cratægus.

(2) Experiments with apple root forms indicate that there may be from six to twelve generations a year in the Ozarks.

(3) Elms have acquired a strong degree of immunity against this species. Susceptibility to attack seems to be correlated with backwardness of growth in the spring.

(4) *Cratægus crus galli* is largely immune to the insect, the condition of immunity being apparently inherent in some instances and conditional in others.

(5) Northern Spy stock is immune to the species.

(6) Apterous viviparіæ from Cratægus will establish on apple and apterous viviparіæ from apple will establish on Cratægus though the Cratægus individuals do not establish as readily on apple as do the individuals from the same host.

(7) Based on a study of the antennæ, the writer's data indicate that *Eriosoma cratægi* Oestlund is a synonym of *Eriosoma lanigera* Hausmann.

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[1]Report No. 101, U. S. Department of Agriculture, Office of the Secretary, 1915.

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THE CHIGGER-MITES AFFECTING MAN AND DOMESTIC ANIMALS

By H. E. Ewing and Albert Hartzell, *Ames, Iowa*

Although the chigger-mites are widely known over the world on account of their attacks on man and domestic animals, yet, because of their minute size, they have been remarkably exempt from thorough investigations which usually have been applied to pests of so much economic importance. In Europe, due chiefly to the work of Dr. Oudemans and to Berlese, we have recently learned much of the taxonomy, biology, habits, and distribution of the foreign chigger-mites.

As is well known among entomologists, chigger-mites are the larvæ of the brilliantly colored harvest mites, which, according to acarologists, are placed in the family Trombidiidæ. This fact, however, was not known when many of our common chiggers were first described, or if known was not heeded. When these early descriptions were made, the larval characters of real taxonomic importance had not been worked out, so that these descriptions have proved to be all but valueless to us today, notwithstanding we now have an excellent key to the chiggers based on larval characters.

In this paper it has been the object of the writers to give a summary of the important biological and other facts concerning the chigger-mites known to affect man and domestic animals, together with references to a few important species found in this country which so far have not been recorded from these hosts. To the recorded observations of others we will add what we have learned of our American chiggers. Some of the species here mentioned have not been sufficiently known in the past to have acquired common or popular names, hence one of our chief tasks has been to get appropriate common names for these less known chigger-mites.

The Summer Chigger of Europe

[*Metathrombium poriceps* (Oudemans)] (Fig. 10*a*)

Chigger-mites have been studied more in Europe than in America, and it is now known that at least three different species are concerned in the attacks upon man and domestic animals. Of these three species, two are quite common, one attacking in the summer time, the other in the fall.

The summer chigger-mite of Europe is a very small creature not more than 0.4 mm. in length when unengorged. It is egg-shaped, and has above on the thorax two porous chitinous plates or shields.

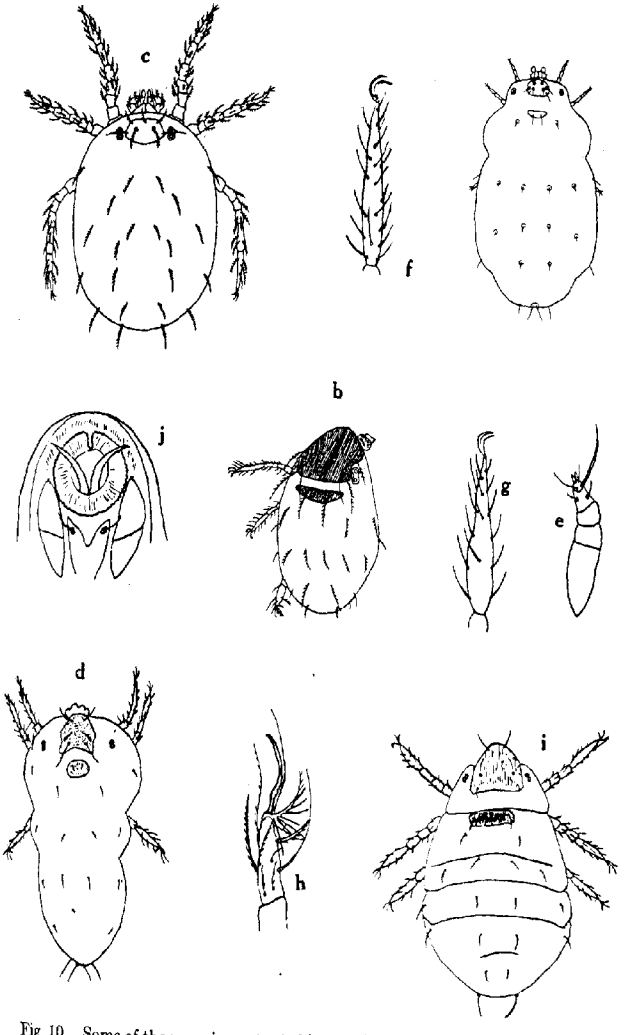

Fig. 10. Some of the more important chigger-mites. *A*, *Metathrombidium pericepts* (Oudemans), dorsal view; *b*, *Thrombidium striaticeps* Oudemans, dorsal view; *c*, *Microthrombidium tlalzahuatl* (Murray), dorsal view; *d*, *Euthrombidium trigonum* Hermann, dorsal view; *e*, right palpus from above; *f*, tarsus I of left leg; *g*, tarsus II of left leg; *h*, tarsus III of right leg; *i*, *Thrombidium muscarum* Riley, dorsal view; *j*, ventral view of mouth-parts. Figures *a*, *b*, *c*, and *d* after Oudemans. Remaining figures drawn from nature by Hartzell.

This chigger has been frequently reported from man. It also has been taken from the dog, and from chickens. Among the invertebrate hosts we find the house-fly (*Musca domestica*), many small dipterous insects as well as insects belonging to the following orders: Orthoptera, Ryhnchota, Diptera, Coleoptera, Lepidoptera and Hymenoptera. It has been recorded from spiders, from rodents, and from various mammals. This mite has been collected during the months of June, July, August and September. It is found in the Netherlands, France and Germany; and doubtless occurs in other parts of Europe.

The European Autumnal Chigger

[*Microthrombidium pusillum* Hermann]

It is the autumnal chigger-mite that has become noted because of its attacks on man and beast in Europe. This chigger-mite was long known under the name of *Leptus autumnalis*, and gave rise to a severe rash or itch which was called "erythema autumnale."

When unengorged these chiggers are very minute, being scarcely visible to the naked eye. They are brick red in color, and have above one dorsal median shield, which is trapezoidal in shape.

It was for a long while believed that this mite, as well as chiggers generally, lived on the juices of plants and that only under certain conditions did it become blood thirsty. C. V. Riley shared this belief with others, and stated as follows in regard to one of our American chiggers: "I have stated my belief that its normal food must, apparently, consist of the juices of plants and that 'the love of blood proves ruinous to those individuals who get a chance to indulge it.'"

The belief that chigger-mites lived normally on the juices of plants gained credence no doubt largely on account of Claparede's contention that they belonged to *Tetranychus*, a genus composed of plant-feeding acarids.

This chigger, like all other species of its genus, lives normally upon invertebrate hosts, especially insects, and is an accidental parasite only on higher animals. Besides being especially severe when on man, it is troublesome to horses, cattle, sheep, rabbits, dogs, and cats. When first attacking they attach themselves by means of their claws and palpi. Around the attached chigger, swellings are said to develop which may be as large as a pea or larger, and there is severe itching. It has been stated that fevers result at times after mite attacks, hence it is believed by some that this species, as well as others, gives off a toxin. This chigger has been reported for the months of September, October, and November.

Various insects are reported as being hosts for this mite, and are probably the normal ones. Among the other hosts reported are dif-

ferent birds and mammals. Oudemans has compiled a list of fourteen determined host species. To this should be added a larger list of hosts that were only determined to the genus or family. The species is reported from England, France, Belgium, Holland, and Germany.

The Striated European Chigger

[*Thrombidium striaticeps* Oudemans] (Fig. 10*b*)

There is another chigger-mite of Europe known to attack man and domestic animals. It does not appear to be as common or as important a pest as the two just considered. This chigger has parallel striations on the dorsal shields or plates. The larvæ are egg-shaped, and when somewhat swollen with blood are about 0.5 mm. in length.

This chigger has been found on man, the dog, the cat, and the domestic fowl. Its normal hosts are for the most part dipterous species. It has been reported from France, Belgium, and Holland.

The Kedani Mite

[*Microthrombidium* sp.]

In certain parts of Japan there is a chigger-mite that has been associated with a fatal disease known as river fever or flood fever. Tanaka, especially, insists that there is a connection between these mites and this disease. It appears that the mites by their attacks produce lesions which become points of entrance for certain bacteria which are the real cause of the fever. At the point of attack there is a papule which becomes surrounded by an inflamed area. This is followed by a pustule which gives way to a black scab.

The mites concerned are orange-red, and measure about 0.2 mm. in length when not engorged. The palpi are strong and single clawed. The legs are stout, and each is provided with three tarsal claws, the middle one being longer than the rest. The femora are divided. Above, the body is clothed with about thirty long doubly pectinate hairs.

The kedani mite appears to be a *Microthrombidium* species according to Tanaka's figure. Yet he does not show some of the more important taxonomic characters. The adult form is unknown.

The Ceram Chigger

[*Microthrombidium wichmanni* (Oudemans)]

Two chigger-mites are found in the East Indies that according to the various but authentic reports of different travelers must cause a scourge which is far more severe than any caused by the species of the temperate zones. One of these mites, it appears, is the species

which Wallace mentions in his work on the Malay Archipelago as causing him to come down with a serious disease while on his first visit to Ceram. For this reason we shall call this species the Ceram chigger.

In this species there is a single median shield present without crista. There is only one pair of psudostigmata. The tarsi have two thick and one thinner and longer claw. Two eyes are present.

Oudemans states that this species was collected in New Guinea in separate lots on the head of *Goura* sp., where they had fastened themselves to the skin by the hundreds in regular rows, like paving stones. They had caused the feathers to fall from the infested region.

Alfred Russel Wallace gives his experiences with a species in Ceram which it appears is the one under consideration. He states: "All the time I had been in Ceram I had suffered much from the irritating bites of an invisible acarus, which is worse than mosquitoes, ants and every other pest, because it is impossible to guard against them. This last journey in the forest left me covered from head to foot with inflamed lumps, which after my return to Amboyna, produced a serious disease, confining me to the house for nearly two months."

Besides being found on man, this chigger has been recorded from *Goura coronata*. Authentic records of the species are from New Guinea and the Celebes. In addition we have Wallace's report from Ceram which probably concerns this species.

The East Indian Shrub Chigger

[*Schöngastia vandersandei* (Oudemans)]

In this country the chigger-mites are found almost entirely in the grass, even short grass at times harboring them. In New Guinea there is a chigger that climbs shrubs and bushes where it is brushed upon the bodies of larger animals as they pass by.

It is a bright red chigger with a single, trapezoidal, dorsal shield. The coxæ each have one hair. The dorsal shield is convex behind; palpal claws two or three partate. Mandibles claw-like, long, straight and toothed.

This species causes a disease known in New Guinea as shrub-itch. Wayfarers brush the almost invisible mites onto their bodies from the low hanging branches of trees or from shrubs. The mites are said to get under the skin, and to cause a terrible irritation. Besides occurring on man, the shrub-chigger has been found on *Goura coronata*. It is common in New Guinea, and probably occurs in neighboring islands.

The Mexican Chigger-Mite

[*Microthrombidium tlalzahuatl* (Murray)] (Fig. 10c)

The Mexican chigger mite has been known to entomologists through our scientific literature for half a century, and due to the efforts of Oudemans we now have most excellent figures of it. This mite was originally described by Murray in his well-known volume on "Economic Entomology—Aptera" although it was mentioned earlier by Lemaire who has given us an account of its accidental introduction into France at an early date.

The larvæ are a bright yellow orange, and the body is oval in shape, being evenly rounded at either end. There is a single shield above; and the rather conspicuous palpi each end in a bifurcate claw.

This mite is said to occur in the more temperate parts of Mexico, and is not found in the hot dry regions. It attacks the eyelids and armpits especially and apparently through predilection. The Indians, it is stated, remove these chiggers by means of a fine grass stalk when a needle is not obtainable.

The natural hosts of the mite have not been determined, and we have no record of it attacking other mammals than man, but it very probably does. Osborn has suggested that this species may be distributed over parts of the Southern States. The chiggers which the senior writer has so often encountered in Mississippi do not attach at the eyelids or armpits, but about the ankles and calves of the legs.

The American Chigger-Mite

[Genus? Species?]

We have at least two species of chiggers in the upper Mississippi Valley which attack man. This was shown by no other than C. V. Riley who obtained his original material from the superficial anatomy of one, Otto Lugger,—well-known American entomologist. Riley described one of these species under the name of *Leptus americanus* and the other under the name of *Leptus irritans*, and gave figures of each. The figures of Riley's have been copied many times, and are familiar to most of you present at this meeting. It is almost lamentable that from them one can get hardly a character which is used today in specific diagnosis of chigger-mites. As the two mites were not reared we are left in doubt to this day as to their identity.

Riley's *Leptus americanus* was a very small chigger for he states: "This species is barely visible to the naked eye. . . ." It has a slender body, rounded behind and pointed in front. The legs were very long and slender. Although the present writers have observed many harvest mite larvæ in Iowa, we have failed to find any liable

to attack man, which look similar to Riley's drawing of his *Leptus americanus*.

Riley states that this mite infests chiefly the scalp and armpits, that it does not bury itself in the flesh, but simply insinuates the anterior part of its body under the skin. The method of attack given by Riley at once suggests the Mexican chigger, but if you will compare Riley's figure with Oudeman's drawing of the Mexican chigger you can see at once that they are different species. The Mexican chigger is a broad, stout species, with moderate legs, while Riley's drawing of *americanus* shows the legs longer than the body. We know nothing of the natural hosts of the mite or if its distribution other than that it is found in the upper Mississippi Valley.

The Irritating Chigger-Mite

[Genus? Species?]

This species, which has long gone under the name of *Leptus irritans* Riley, has been most frequently mentioned in our American literature. Riley says of it: "This is the most troublesome and perhaps best known of the two (the other species being his *Leptus americanus*) causing intense irritation and swelling on all parts of the body. . . ." We have made many attempts to place this species of Riley's but have failed. It can not be placed even in the proper genus, as we recognize the genera of Trombidiidæ today.

The irritating chigger according to Riley's figure and description is of minute size, but has a broad body and very large palpi. Indeed the palpi, as shown in Riley's figure, are larger in proportion to the body than in any of our known species.

Since Riley, as well as others, speaks of this chigger as being so common and so troublesome it may be thought by some that it is no other than our common locust chigger so frequently found on the wings of grasshoppers in the upper Mississippi Valley. This point has been tested here at Ames by letting these locust chiggers crawl over the bare arms and legs without effect. Individuals have gone through grass heavily infested with these locust chiggers with the trousers rolled up at the bottom and with the socks rolled down at the top, but without a single attachment. Many men have been observed working in areas infested with these chiggers, but they have not complained of being attacked. Just what species Riley's *irritans* will prove to be we cannot say. It very probably will never be known for a certainty.

The Locust Mite

[*Euthrombidium trigonum* (Hermann)] (Fig. 10*d*, *e*, *f*, *g*, and *h*)

The larvæ of this species were first reported from Omaha, Nebraska,

by Riley, in 1868, on the Rocky Mountain locust. The following year it was reported from Oregon and Missouri. In May, 1874, the adult was observed attacking the eggs of the Rocky Mountain locust in northwestern Iowa. It was recognized by Riley as *Trombidium sericeum* Say. At that time the immature stages of the TROMBIDIIDÆ were unknown. In the same report he recognized the larval form, of what afterwards proved to be the same species as the above, as *Astoma gryllaria* LeBaron. Riley was the first to work out the life-history of the locust mite. In 1878 he published a description of it as a new species under the name *Trombidium locustarium*. Banks, however, considers it a synonymn of *Astoma locustarium* Walsh. In 1912 the senior writer sent an adult locust mite to Berlese, who determined it as *Euthrombidium locustarium* Walsh. A larva of the same species, taken from *Melanoplus differentalis*, was sent to Dr. Oudemans, who recognized it as nothing less than the European *Euthrombidium trigonum* Hermann. Since Oudemans based his determination on larval characters, which in this group are more definite than adult characters, we believe it to be correct. Furthermore, we have carefully compared Oudeman's and Berlese's descriptions and figures with our own material of this species and conclude that *Euthrombidium locustarium* Walsh is synonymous with *Euthrombidium trigonum* Hermann.

The larvæ of the locust mite may be distinguished from the other members of the genus by the bifurcate coxal spurs and the four hyaline lobes on the cephalic border of the front dorsal shield.

Riley was first to study the biology of this species. The senior writer has also carried on life-history experiments with this mite, and succeeded in rearing an adult from a larva infesting *Melanoplus bivittatus*. The adults showed a decided preference for grasshopper eggs. In no case could the mites be induced to attach themselves to man. It is also of interest to note that this mite has never been reported from man or domestic animals in Europe.

As far as is known the hosts of the locust mite are confined to four families of Orthoptera, namely: ACRIDIIDÆ, LOCUSTIDÆ, GRYLLIDÆ and MANTIDÆ. It has been found on the following species of grasshoppers in this country: *Melanoplus differentialis, M. spretus, M. augustipennis, Spharagemon bolli, Schistocerca americana.*

Euthrombidium trigonum is generally distributed throughout Minnesota, South Dakota, Iowa and Illinois. It has been reported from Nebraska, Kansas, Missouri and Oregon. It has also been found in Germany and Holland.

The House-fly Chigger

[*Thrombidium muscarum* Riley] (Fig. 10 *i*, *j*)

The larvae of this species were recognized by Riley, in 1875, as *Astoma parasiticum* Latreille. Two years later a description of it was published in the Report of the United States Entomological Commission as a new species under the name *Trombidium muscarum* Riley. We have carefully examined the larva of his form and believe that the species is valid, and should be retained in the genus *Thrombidium*. This genus may be distinguished by the presence of two median dorsal shields. The front shield is furnished with eight setæ and has longitudinal striations.

During some seasons scarcely a house-fly can be found that is not infested with a number of these mites. Riley succeeded in rearing the adult. The senior writer has also reared the adult of this species.

As far as known this mite is confined to a single host, *Musca domestica*. It could never be induced to attach to man. Apparently this chigger is generally distributed throughout the United States. We have records from New York, Illinois and Iowa.

Summary

1. Six separate and distinct species of chigger-mites taken from man and domestic animals have been accurately described, figured and named. Three of these are found in Europe, two in the East Indies and one in Mexico.

2. At least two distinct chigger-mites are known to attack man in this country. We have been unable to place either one of these species in our modern classification of the chigger-mites, and are in doubt in regard to their specific identity.

3. The common locust mite in the United States is the same as the common locust mite of Europe, hence *Trombidium locustarium* Walsh is a synonym of *Euthrombidium trigonum* (Hermann) of the old world. Observations and experiments have shown that this species does not attack man.

4. The scientific name of our house-fly chigger, *Thrombidium muscarum* Riley, still stands, the species being good.

5. Only two species of our American chigger-mites have been reared to maturity.

6. A thorough survey of our chigger-mite fauna, with notes on hosts and geographical distribution is most needed at present.

FERTILIZATION OF QUEEN BEES

By C. W. HOWARD and L. V. FRANCE, *University Farm, St. Paul, Minn.*

The possibility of controlling the fertilization of queen bees has been in the minds of beekeepers for many years. From time to time it has been brought about under artificial conditions, the life of the queen being thereafter perfectly normal and in accordance with that of one fertilized by a male in the usual manner. Several stories have come to the writers stating that the queen could be taken at the time she was leaving the hive, held between the fingers of one hand while the organs of a mature drone were pressed out with the fingers of the other and the mass of spermatic fluid which exuded dropped into the open extremity of the queen. Fertilization took place in an apparently normal manner and the queen was accepted by her colony and remained alive one or two seasons producing worker brood in large quantity. In the reports of the U. S. Department of Agriculture for 1885 and 1886 and of the U. S. Commissioner of Agriculture for 1887 are reports of various methods adopted in attempts to artificially fertilize queen bees. A large number of successes were claimed. The method followed was that described above and queens from one to fifteen days old were used. In the *American Bee Journal* in November, 1878, appeared a third report by Mr. J. Hasbrouck, in which he claimed to be able to cause queens and drones to mate when confined in small glass boxes.

This work done between 1885 and 1887 seems to have been discredited. The possibility of accomplishing this feat was again broached by Professor Francis Jager in 1914 and the senior author was asked to coöperate in the work. In the number of *Science* for November 13, 1914, a preliminary report upon a successful case of artificial fertilization was published. Since that time the writers have attempted to successfully repeat the experiment, but have almost uniformly failed. The advantages, both to the practical beekeeper and the student of genetics, if this could be done are obvious and need not be detailed here.

The queen bee reported on in *Science* in 1914 wintered in good condition, but soon after removal to the open in the following spring she began to lay drone eggs as well as worker eggs and finally produced exclusively drone eggs. After this had continued for three weeks she was killed and the contents of the spermatheca examined. It was packed with live active spermatozoa, showing conclusively that fertilization had taken place. If left alive she would have probably soon resumed the production of worker eggs.

During the summers of 1915 and 1916, 55 duplicates of this experi-

ment were carried out, making a total of 63 experiments. Of these, aside from the one already recorded, three were partial successes, the remainder were failures. Twenty-six queens died or were killed by the workers a few days after they were fertilized and before sufficient time elapsed to allow of egg production. The remainder laid eggs in sufficiently large quantity to ascertain the sex of the progeny or else the queens were killed and opened, after a few drone eggs had been laid, and the spermatheca found to contain no spermatozoa.

The method followed in the operation was as follows: Being unable to secure successful manipulation by squeezing out the drone organs and allowing the spermatic fluid to drop into the posterior chamber of the female, we carefully dissected out the seminal vesicles of mature drones, using sterile instruments to mix the contents with a drop of sterile salt solution (0.75 gr. to 100 cc. H_2O). In the later trials the salt solution was not used, its purpose being merely to dilute the spermatic fluid for greater facility in handling. During cool weather the instruments were kept warm. If the spermatozoa were inactive the material was discarded and a new preparation made. The queen was held loosely between the fingers of the left hand, the posterior end upward. With the right hand a capillary tube into which the spermatic fluid had been drawn was then inserted into the bursa copulatrix of the queen and the contents gently forced into the vagina by pressure from the mouth. The queen was then placed in a queenless colony and left under normal conditions, except that a queen excluder was applied to the hive next to the bottomboard.

To prevent the possibility of natural fertilization each queen was taken as soon as she emerged from the queen cell and one or both pairs of wings clipped off. All drones were removed from the hives and a queen excluder kept on. Queens were taken at all ages, varying from two to thirty-five days, although the majority were treated at the age of six to seven days. During 1916 practically all the queens were fertilized at the time when they were trying to leave the hive, apparently for the marriage flight.

Only mature drones were used. Careful observations showed us that drones were mature and spermatozoa active when they were five to six days old, but most of those used were ten days or more of age and had had several flights.

Where queens laid eggs from eleven to forty days intervened between the attempted fertilization and egg laying, with an average of twenty days. During 1916 whenever a queen attempted to escape from the hive for a flight she was refertilized. In this way some were operated upon two to three times, but still with no results.

The three partial successes were as follows: One thirteen-day-old

queen was fertilized after the method described. After an interval of twenty-six days, although the abdomen was enlarged, no eggs had been laid and the female appeared sick. She was killed and the spermatheca examined. It was found quite full of spermatozoa. The second case was that of a queen whose age was not known at the time of fertilization. Seven days later she was found in the queen trap trying to escape from the hive and was refertilized. Several of her eggs produced worker larvæ and five eggs were placed in queen cells. All of these were capped over, but robbers destroyed the colony preventing complete observations. A third case was a six-day-old queen which after an interval of forty days began to produce eggs, about 5 per cent of which produced worker bees and the remainder drones. During the interval between the first attempted fertilization and egg laying she three times tried to escape from the hive and each time was refertilized. It was only after the last attempt that her abdomen began to enlarge and she prepared for oviposition.

If this operation can be done once it would seem that we ought to be able to repeat it with successful results. This led to a closer examination of the female organs. Our observations agree with those of other investigators as to the existence of the S-shaped bend and muscular pump in the spermathecal duct. This probably prevents the forcing of the spermatic fluid into the spermatheca. There is undoubtedly a time or a natural stimulus which causes this valve to open and if the operation can be performed at this time the fluids will enter. The problem is to find when this takes place. So far we have been unable to determine this point.

Our results would indicate that if the mating of queen bees is to be controlled it must be done in some other way than the one followed by us.

On account of the presence in some of the North Atlantic States of *Laspeyresia molesta* Busck, a serious pest of deciduous fruits, a conference was held Monday, March 18, in the office of Dr. A. L. Quaintance, Bureau of Entomology, Washington, D. C. The following were in attendance: Prof. W. J. Schoene, Blacksburg, Va.; L. M. Peairs, Morgantown, W. Va.; Prof. E. N. Cory, Dr. Philip Garman, College Park, Md.; Prof. C. A. McCue, Newark, Mr. Wesley Webb, Dover, Del; Dr. T. J. Headlee, New Brunswick, N. J.; Dr. W. E. Britton, New Haven, Conn.; Dr. A. L. Quaintance and Messrs. Whitcomb and Wood of the Bureau of Entomology.

Scientific Notes

On the Life-History of Sarcophaga eleodis Aldrich. On September 13, 1916, the writer was collecting material for study of the life-history of several species of Eleodes at a point some five miles northwest of Maxwell, New Mexico. The adults were quite numerous at this time (about 3.30 p. m.) along the roadsides and, because of the scant vegetation, could be seen for some distance, particularly from horse back.

A specimen of *Eleodes obsoleta* was about to be picked up when an adult Sarcophagid was observed closely following the beetle, about an inch behind. The beetle was watched for nearly fifteen minutes during which time it traveled at least eight feet, being constantly in motion and followed persistently by the fly.

Finally the beetle reached the main stem of a Russian thistle and rested. The fly immediately mounted its back, facing in the same direction, and remained there for about four minutes while it larviposited on the posterior tip of the left wing cover. The beetle remained quiet for about two minutes longer, when it moved the tip of the abdomen, thereby exposing the anus. At once the larva became active and, in the merest fraction of a second, had disappeared within the body of the beetle through the anus.

The beetle thus attacked lived for thirteen days, dying on September 26, and on the 28th the full-grown larva issued, breaking off the head of the host in doing so. On March 12 the larva had entered the pupa stage, from which the adult fly emerged on April 3, 1917.

GEO. W. BARBER,
Scientific Assistant, Bureau of Entomology,
U. S. Department of Agriculture

Brown-tail Moths Taken on Importations. While inspecting a large importation of nursery stock, during the first week in February, I took a complete nest of the brown-tail moth (*Euproctis chrysorrhoea* Linn.) on European mountain ash (*Sorbus aucuparia*). Within the nest of silk and leaves was a large number of live hibernating caterpillars. Had this nest of one of our most destructive imported pests been permitted to remain on the host tree and planted in the extensive nursery in the spring, we would have had another infestation in a short time to rival the most serious one now in New England states. This latter infestation is the cause of hundreds of thousands of dollars' damage each year to the trees and property valuation within the infested area.

In view of this we should use every precaution to prevent another infestation by having all importations closely inspected by thoroughly trained men or still better have Congress realize the importance of passing a quarantine law which would prevent the importation of all nursery stock which carry destructive pests. This latter plan cannot be over-emphasized to our Senators and Representatives in Washington at present. We can no longer afford to lose such extensive and increasing amounts of property each year due to the rising number of imported insect pests and plant diseases.

During the European conflict foreign inspection of nursery stock is likely to be somewhat imperfect, so we must as protectors, give more careful attention to all horticultural importations.

T. M. TRIMBLE, *Dep. Nursery Inspector,*
Bureau of Economic Zoölogy,
Primos, Delaware Co., Pa.

Molasses Sprays for the Control of Monarthropalpus buxi Labou.[1] On May 25, 1915, molasses sprays for the control of the boxwood midge were applied to a hedge in Baltimore at 6 p. m. Two strengths, one pound and four pounds to fifty gallons of water were used. Examination at 8 a. m. showed large numbers of the adults entrapped in the spray on the surface of the leaves. The greater number were caught in the spray containing four pounds of molasses. The sprays were applied too late to reach the maximum number of adults in flight as the maximum emergence occurs from May 10 to 15. It was planned to spray the entire hedge the following spring but during the winter the hedge was cut down and it was found impossible to continue the tests. The preliminary results are, therefore, offered in the hope that others may be able to test this control measure more extensively.

E. N. Cory.

Notes on a Spirea Leaf-roller. *Olethreutes hemidesma* Zeller is not generally recognized as being of any particular economic importance. Arthur Gibson (36th Rep. Ent. Soc. Ont. 119) has mentioned its abundance at Ottawa, Ontario, Canada, and J. J. Davis (Journ. Econ. Ent. 3–185) has reported its injury to Spirea Van Houtii in Illinois. These two records seem to be the only references in the economic literature.

In July, 1916, these leaf-rollers were common on spirea at Ames and specimens brought to the insectary by Prof. J. E. Guthrie were at once placed in breeding cages. August 30, 1916, they were abundant and causing considerable injury to spirea in a nursery near Cedar Rapids, according to Ivan L. Ressler. In July, 1917, the insect was again common at Ames. Prof. B. M. Harrison reported the insects common on spirea at Shenandoah, Charles City, Washington and Cedar Rapids during the summer. The species appears to be common generally over Iowa.

There are evidently two generations in Iowa. Larvæ are recorded as abundant in July and again late in August and during September. They were most common in July. Davis says that two generations occur in Illinois.

From insectary records taken in 1916 and 1917, moths emerged from July 22 to August 9, according to notes taken by H. R. Werner and Ivan L. Ressler. Only one moth was reared in the fall, emerging September 28; 5 to 8 days were spent as pupæ in the summer, with an average of 5.8 days, from 17 records. In September, 8 days were spent as the pupa, but only one record is available. R. L. Webster.

The Agricultural Index. A cumulative index to agricultural periodicals and bulletins, cumulated quarterly, is a new undertaking in bibliography, indexing some 78 journals. It is a reference work covering a wide range of topics and therefore most serviceable to the general worker though of much value to specialists because of its references along cognate lines. It is probable that experiment station libraries and many of the larger libraries of the country possess copies of the index and it is therefore presumably accessible to most economic entomologists.

[1] Contribution from the Entomological Laboratory, Md. Agr'l Exp. Sta.

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

APRIL, 1918

The editors will thankfully receive news items and other matter likely to be of interest to subscribers. Papers will be published, so far as possible, in the order of reception. All extended contributions, at least, should be in the hands of the editor the first of the month preceding publication. Contributors are requested to supply electrotypes for the larger illustrations so far as possible. Photoengraving may be obtained by authors at cost. The receipt of all papers will be acknowledged.—Eds.

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The opening of another season under war conditions is a challenge to economic entomologists or entomological engineers to justify once more the great practical value of their calling. There will be unexampled opportunities to discriminate between essentials and the comparatively unimportant and it is quite within possibilities to render more service by advising a modified and reduced spraying program designed to control the more serious insect pests, than to advocate a theoretically perfect schedule impractical under present day limitations.

There is more need than ever to watch developments for the purpose of anticipating and effectively controlling insect outbreaks in their incipiency. There should be more expert field entomologists stationed at important crop centers and working in closest coöperation with county agents and various agricultural organizations. The entomologist should demonstrate that one of the most effective methods of increasing crop production is by crop conservation. It is hoped that the organized work of last year conducted under the direction of federal and state authorities may be greatly extended the coming season, though there will probably be greater difficulty in securing enough well qualified men than last year.

Reviews

Field Book of Insects, with special reference to those of northeastern United States, aiming to answer common questions, by FRANK E. LUTZ. Pages I to IX, 1 to 509, about 800 illustrations, many in color. G. P. Putnam's Sons, New York and London, 1918. 12°. Price, $2.50.

This study in concision and clarity, withal interesting, delightfully so in places, discusses in less than 500 small pages, about 1,400 insects, gives 800 illustrations and touches many of the more interesting biologic, economic and systematic phases of insect life. The book bears the impress throughout of a field naturalist, possessed of a healthy skepticism concerning certain "stock" explanations and he who has felt the call of the wild will find therein much suggestive and inspiring. One notes here and there the reaction of fiction on one phase of science.

The author speaks a good word for the scientific name, though he is not above using common designations. He has dared to be inconsistent with his treatment of various groups, giving keys in some, none in others and though explaining the fundamentals of classification, he has not hesitated to discuss groups or even individual insects from the popular or even historical aspect,—the matter being admirably adapted to the limitations and possibilities of the forms considered. The large number of illustrations go far toward making up for the absence of a glossary to explain the technical terms of the simplified keys. The excellent indexes, habitat and plant and entomological, are extremely serviceable in locating information grouped under the hundreds of names.

There are some errors, presumably some omissions and yet most entomologists will feel that in this little volume they have an exceedingly interesting compilation, while the beginner could hardly find a better introduction to the exceedingly abundant and very important group of animals known to the lay man under the somewhat contemptuous term of "bugs" (*Advt.*).

E. P. F.

Current Notes

Conducted by the Associate Editor

R. K. Vickey is a private in the sanitary corps at camp Meade.

Mr. A. O. Larson, assistant entomologist at the Utah Station, has resigned to accept a position in the high school at Manhattan, Mont.

Dr. W. A. Riley of Cornell University has been appointed professor of parasitology and chief of the Division of Economic Zoölogy at the University of Minnesota.

The Fifth Annual Meeting of the New Jersey Mosquito Extermination Association was held January 31 and February 1 at the Hotel Traymore, Atlantic City, N. J.

P. H. Luginbill, U. S. Bureau of Entomology, Columbia, S. C., has been requested by the medical director of Camp Jackson to give part of his time to camp problems.

According to *Science* Dr. W. D. Hunter of the Bureau of Entomology has been elected a vice-president of the Washington Academy of Sciences, representing the Entomological Society.

Mr. Wallace Park, a graduate of the Kansas State Agricultural College, has been appointed assistant in apiculture in the Iowa Agricultural Experiment Station and entered on his duties February 1.

Mr. W. H. Larrimer, Bureau of Entomology, formerly attached to the West Lafayette, Ind., field laboratory, has been granted an indefinite furlough in order to enter an officers' training camp.

Rev. Harry R. Caldwell has recently presented the American Museum of Natural History with a collection of about 8,000 insects from China, in appreciation of which he has been made a life member.

Mr. A. J. Flebut, Bureau of Entomology, who has been in charge of the work on chestnut weevils, with headquarters at Paxinos, Pa., has been granted an indefinite furlough for the purpose of entering the Officers' Training Camp at Camp Upton, N. Y.

According to *Science*, Mr. Charles A. Hart, systematic entomologist of the Illinois State Natural History Survey, died suddenly of heart disease on February 17. He was an active member of this Association, and a member of the American Society of Zoölogists.

Professor A. G. Ruggles, associate entomologist of the Minnesota University and Station, has been appointed state and station entomologist of Minnesota vice F. L. Washburn, who at his own request was granted relief from the position and its attendant police duties.

Dr. Clarence Moores Weed of the State Normal School, Lowell, Mass., formerly professor of Entomology and Zoölogy at the New Hampshire College, Durham, N. H., has been called to Washington, D. C., to take charge of the school gardens of the city during the coming season.

Mr. Frank J. Rimoldi, a recent graduate of Cornell University and a former student of the Connecticut Agricultural College, has been appointed by the Federal Bureau of Entomology as extension entomologist for work on deciduous fruit insects in Massachusetts, Connecticut and Rhode Island.

Entomologists have been commissioned first lieutenants in the army as follows: L. H. Dunn, Army Medical School, Washington, D. C., E. H. Gibson, Camp Humphrey, Va., A. H. Jennings, Camp Shelby, Miss., H. L. Parker, Camp Lee, Va., D. L. Van Dine, Camp Travis, Tex., and Neal F. Howard.

The Brooklyn Entomological Society recently elected officers for 1918 as follows: president, W. T. Bather; vice-president, W. T. Davis; treasurer, Chris. E. Olsen; recording secretary, J. R. de la Torre Bueno; corresponding secretary, R. P. Dow; publication committee, R. P. Dow, editor; C. Schaeffer and J. R. de la Torre Bueno.

Mr. Quincy S. Lowry, assistant entomologist of the Connecticut Agricultural Experiment Station, resigned March 1 to accept a position as extension entomologist with the Federal Bureau of Entomology. Mr. Lowry will work with truck crop insects and will cover Massachusetts, Rhode Island and Connecticut, with headquarters at Amherst, Mass.

Professor Francis Jager, chief of the bee division of the Department of Agriculture of the University of Minnesota, has been granted six months' leave of absence to head a group of men who are to go to Serbia to direct farming operations on a large tract of land. Seed, agricultural machinery and tools will be carried from this country, and preparations are practically completed for transportation facilities.

According to *Science*, Professor William B. Herms, professor of parasitology and acting head of the Department of Entomology, University of California, has been appointed captain in the Sanitary Corps, National Army, and has been ordered to Fort Sam Houston, Texas, for duty. Captain Herms was actively engaged during the past summer and autumn in investigating the sanitation of military camps in the Western Department, particularly as regards mosquitoes and flies.

The lecture course of the California Academy of Sciences included the following lectures by entomologists: January 20, "Forest Insects" (illustrated), by Professor R. W. Doane of Stanford University; January 27, "Experiences in a Georgia Swamp" (illustrated), by Professor J. C. Bradley of Cornell University, but for the college year at the University of California; March 10, "Pine Insects and Their Depredations," by Mr. Ralph Hoppin of the United States Forest Service.

The following resignations from the Bureau of Entomology have been announced recently: C. S. Whittington of the boll-weevil laboratory; H. K. Laramore, special field agent, College Station, Tex., to accept a call to the colors; E. G. Smyth, to accept a state position as extension entomologist in Texas; H. L. Dozier, Tempe, Ariz., to complete his work for a doctor's degree in Florida; E. O. G. Kelly, Wellington, Kan., to enter private business; David Running, apiculture, on account of illness; J. H. Wagner, apiculture; E. P. Barrios, special field agent, extension work in Southern Louisiana; R. C. Pickett, special field agent, extension work in Texas.

The following transfers have been made in the Bureau of Entomology: to the Federal Horticultural Board for temporary work on the pink boll-worm in Texas; U. C. Loftin, H. P. Smith, K. B. McKinney and Tobert Slack; W. M. Davidson,

Sacramento, Calif., temporarily to Alhambra, Calif., for work on coccinellids; Messrs. Edmonston and Hofer, temporarily from Colorado Springs, Col., to Tuscon, Ariz., for work on insects destructive to Mesquite cordwood; F. B. Milliken, Wichita, Kan., to New Orleans, La., mill and grain storage insects; D. E. Fink, Norfolk, Va., to Riverton, N. J., in charge of a new field station for work on truck crop insects; J. D. Smith, southern field crop insects, Valdosta, Ga., to deciduous fruit insects, Washington, D. C.; T. C. Barber, Federal Horticultural Board, to southern field crop insects, Audubon Park, New Orleans, La.; Charles E. Smith, Muscatine, Iowa, temporarily to College Station, Tex.; Marion R. Smith, Plymouth, Ind., temporarily to Baton Rouge, La.; F. R. Cole, Hood River, to Corvallis, Ore.; P. R. Erbaugh, Illinois, to Michigan and Indiana.

The following appointments have been made in the Bureau of Entomology: J. H. Wagner of Colorado, special field agent for apicultural work in Montana, northern Idaho, Washington and Oregon; David Running of Michigan, special field work for apicultural extension work in New York state for the winter season; W. J. Price, formerly of the Virginia Crop Pest Commission, special field agent under the Food Production Act, to take up extension work with deciduous fruit insects in Virginia, with headquarters at Blacksburg; Robert M. Fulton, a graduate of the Washington State College, special field agent under the Food Production Act for work in deciduous fruit insect control in Washington, with headquarters at Pullman; R. C. Pickett of Wisconsin, for work with truck crop insects, College Station, Tex.; C. H. Gable, formerly commissioner of agriculture on the Island of Madeira, specialist on alfalfa insect investigations, Tempe, Ariz.; H. B. Parks, for extension work in cereal and forage crop insects, Texas; A. H. Sherwood, extension work, grasshopper control, South Dakota; H. L. Seamans, extension work in Montana; R. E. Snodgrass, assigned to cereal and forage crop insects; J. R. Horton has been placed in charge of the laboratory at Wellington, Kan.; Rollin La Follette, extension work with citrus fruit insects in California; William T. Ham, special field agent in extension work in Washington and Oregon; R. L. Strand, special field agent in control of cereal and forage crops insects, Montana; F. J. Rimoldi, deciduous fruit insects, and Quincy S. Lowry and George Codding, truck crop insects, extension work in Massachusetts, Rhode Island and Connecticut; W. H. Foster of Colorado, for apicultural work in Montana, Washington and Oregon.

Mailed April 19, 1918.


STATE COMMISSION OF HORTICULTURE
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EXPLANATION OF PLATE 8

GROUP PHOTOGRAPH OF MEMBERS ATTENDING THE PACIFIC COAST BRANCH OF THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS AT RIVERSIDE AND ALHAMBRA, MARCH 28–29, 1918

1, D. B. Mackie
2, G. A. Coleman
3, E. F. Atwater
4, H. P. Severin
5, R. E. Campbell
6, J. D. Neuls
7, A. F. Swain
8, A. S. Hoyt
9, H. J. Quayle
10, H. T. Fernald
11, H. S. Smith
12, E. L. Morris
13, G. P. Weldon
14, G. P. Gray
15, H. J. Ryan
16, R. W. Doane
17, G. S. Demuth
18, C. A. Perrin
19, J. C. Bradley
20, S. B. Freeborn
21, R. S. Woglum
22, E. J. Brannigan
23, H. D. Young

Photograph by C. B. Messenger